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Interdental Cleaning and Oral Health Status in an Adult Cohort, 2015 to 2018

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Abstract

Interdental cleaning is routinely recommended, despite limited evidence supporting efficacy to prevent advanced oral disease endpoints, such as caries and periodontal disease. We aimed to examine associations between interdental cleaning and oral health in a large, generalizable prospective cohort of adults in the United States. Data were drawn from wave 3 (2015 to 2016, $n = 26{,}086$ included in analysis) and wave 4 (2016 to 2018, $n = 22{,}585$) of the adult component (age ≥18 y) of the nationally representative Population Assessment of Tobacco and Health Study. Survey-weighted multivariable regression models estimated the associations between wave 3 weekly interdental cleaning frequency and 6 measures of self-reported oral health—overall rating, tooth extractions, gum bleeding, loose teeth, bone loss around teeth, and gum disease—cross-sectionally and prospectively, with adjustment for established periodontal disease risk factors. As compared with no interdental cleaning, interdental cleaning ≥7 times/wk was prospectively associated with greater odds of excellent self-rated oral health (adjusted odds ratio, 1.37; 95% CI, 1.17 to 1.62), lower odds of bleeding gums (adjusted odds ratio, 0.62; 95% CI, 0.54 to 0.70), but not statistically significantly lower odds of other oral health conditions in the following 12 mo. Older age, lower socioeconomic status, diabetes, and cigarette smoking were consistently associated with worse oral health across all outcome measures. Findings were largely robust to alternative model and variable specifications. Interdental cleaning is associated with better perceived oral health and less self-reported gingivitis. Prevention of more advanced disease states was not demonstrated. These findings should be interpreted cautiously given the self-reported nature of the measures and relatively short follow-up period.

Keywords: oral hygiene, periodontal diseases, gingival diseases, prospective studies, epidemiology, home care dental devices

Introduction

Scientific consensus supports a central role for dental plaque biofilms in the etiology of caries and periodontal diseases (Marsh 1999; Teles et al. 2013; Sanz et al. 2017). Thus, advising patients to disrupt and remove plaque with interdental cleaning devices, toothbrushing, or other means is an enduring tenet of dental education and practice. Studies report that interdental cleaning methods effectively remove plaque and reduce gingival inflammation (Finkelstein and Grossman 1979; Graves et al. 1989; Graziani et al. 2018). Systematic reviews indicate low-certainty evidence that flossing reduces gingivitis and plaque levels beyond toothbrushing alone (Berchier et al. 2008; Worthington et al. 2019), with some evidence suggesting superiority of interdental brushes and oral irrigators over dental floss and wooden toothpicks (Kotsakis et al. 2018; Amarasena et al. 2019; Worthington et al. 2019). However, most studies were short-term (≤6 mo) and assessed low-risk patients (Worthington et al. 2019).

No long-term clinical trials evaluate the impact of interdental cleaning on advanced endpoints among adults, such as alveolar bone loss or tooth retention. Given the ethical and logistic challenges that such trials would pose, observational epidemiology offers critical insight, but epidemiologic findings have been inconsistent. Population-based data from Australia (Crocombe et al. 2012) and Detroit (Lang et al. 1995) suggest that interdental cleaning is associated with less plaque, calculus, and gingivitis but not with periodontal attachment loss. In contrast, recent national studies from South Korea (Lee et al. 2018) and the United States (Cepeda et al. 2017; Marchesan et al. 2018) found that interdental cleaning was associated with better periodontal condition. In longitudinal studies, consistent flossing over time was associated with greater tooth retention among US men (Kressin et al. 2003), but in a Finnish cohort, interdental cleaning and periodontal pockets were no longer associated after adjustment for periodontal disease risk factors (Bernabé et al. 2019).

The present study aims to examine the association between interdental cleaning and oral health outcomes with nationally representative prospective data from the United States. Specifically, we assessed whether frequency of interdental cleaning (flossing or other methods) was associated with 6 self-reported measures of oral health status, cross-sectionally and prospectively.

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A supplemental appendix to this article is available online.

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Methods

Data Source

The Population Assessment of Tobacco and Health (PATH) Study is an ongoing longitudinal study conducted annually beginning in 2013 (Hyland et al. 2017). A 4-stage stratified design based on area probability was implemented with oversampling for young adults, tobacco users, and African Americans; sample weights were generated to generalize to the US noninstitutionalized civilian population (Hyland et al. 2017). Questionnaire items regarding interdental cleaning and oral health were introduced in wave 3 (October 2015 to October 2016) and repeated in wave 4 (December 2016 to January 2018).

Measures

At waves 3 and 4, participants were asked, "Aside from brushing your teeth with a toothbrush, in the last 7 days, how many times did you use dental floss or any other device to clean between your teeth?" Open-ended numeric responses were categorized for this analysis as none, 1 to 2, 3 to 4, 5 to 6, or ≥7 times/wk.

We considered 6 measures of oral health plausibly related to interdental cleaning. Five measures were based on items newly incorporated into the PATH Study at wave 3. At waves 3 and 4, all participants were asked, "Overall, how would you rate the health of your teeth and gums?" on a 5-point scale from "poor" to "excellent," which we specified as excellent versus all other ratings. At wave 3, all participants were asked, "How many of your permanent teeth have been removed because of tooth decay or gum disease?" (later classified as ≥1 vs. none), "Have you ever observed any bleeding after brushing or flossing or due to other conditions in your mouth?" (yes vs. no), "Have you ever had any teeth become loose on their own, without an injury?" (yes vs. no), and "Have you ever been told by a dentist, hygienist, or other health professional that you lost bone around your teeth?" (yes vs. no). The item "Have you ever been told by a dentist, hygienist, or other health professional that you have gum disease?" had been introduced in wave 1. We carried forward responses for this item (including newly reported cases in wave 2 or 3). At wave 4, participants continuing from wave 3 were asked about all 6 of these oral health conditions "in the past 12 mo" rather than as lifetime history. Items related to extractions, bleeding, and loose teeth were asked of all continuing participants, but items related to bone loss and gum disease were asked only of participants who indicated visiting a dentist in the past 12 mo.

Covariables included presumed wave 3 confounding variables: markers of health-promoting behaviors and risk factors for periodontitis. Sociodemographic variables were age, sex, race/ethnicity, household annual income, and educational attainment. Health variables were lifetime history of diabetes, body mass index, and having "your teeth cleaned by a dentist, hygienist, or other health professional" within the past 12 mo. Substance use variables were past 30-d use of alcohol or cannabis and cigarette smoking (never, former, light: 1 to 9 cigarettes/d, heavy: ≥10 cigarettes/d), as well as current use ("some days" or "every day") of electronic cigarettes (any type), noncigarette combustible tobacco (cigars, pipes, or hookah), or smokeless tobacco (moist snuff, chewing tobacco, or snus). The number of drinks categorized as none, light, moderate, or heavy alcohol use, differed by sex (drinks in the past 30 d, respectively—female: 0, 1 to 9, 10 to 29, ≥30; male: 0, 1 to 19, 20 to 59, ≥60).

Statistical Analysis

Eligible for analysis were adult respondents who indicated having no more than 12 total teeth extracted (i.e., ≥20 teeth maintained) and reported their weekly interdental cleaning frequency at wave 3. For cross-sectional analyses, 26,086 eligible respondents answered at least 1 oral health item at wave 3 (of 28,148 total wave 3 observations). For longitudinal analyses, 22,585 also answered ≥1 oral health items at wave 4. Carry forward of wave 1 and 2 gum disease history did not add participants to the analytic sample not already deemed eligible based on wave 3 tooth extraction and interdental cleaning measures.

Separate survey-weighted multivariable logistic regression models were fitted for interdental cleaning at wave 3 (independent variable) and each of the 6 oral health conditions (dependent variable) under 3 designs. The cross-sectional design assessed oral conditions at wave 3 (ever history). One longitudinal design assessed oral conditions at wave 4 (past 12 mo) among all eligible respondents. To assess only new events, the second longitudinal design was restricted to respondents with no history of the relevant oral condition at wave 3. Missing covariable values (1.1% of covariable data) were multiply imputed (15 iterations) with the `mi` command suite in Stata 16.0 (StataCorp). Numeric results were considered statistically significant if 95% CIs excluded an odds ratio of 1.

Robustness Checks

We considered several alternative model specifications. First, we collapsed interdental cleaning in 3 categories (0, 1 to 4, ≥5 times/wk). Toothbrushing is a plausible confounder but was not measured at wave 3. Therefore, we refitted models including wave 4 toothbrushing (less than daily, once daily, twice daily or more). Past 12-mo bone loss or gum disease items were posed only to wave 4 respondents who reported visiting a dentist in the past year. These dental conditions and home interdental cleaning (or cleaning behavioral determinants) are plausible causal antecedents of dental visitation, potentially yielding collider bias: a form of selection bias that results from conditioning on a variable downstream of exposure and outcome (Akinkugbe et al. 2016). While the extent of collider bias is unknowable for these outcomes, to approximate its possible magnitude, we repeated longitudinal analyses for the outcomes asked of all participants (i.e., self-rated oral health, tooth extraction, gum bleeding, and loose teeth) restricted only to respondents with a past-year dental visit and compared with results from the full sample. Finally, to evaluate possible

differences due to weighting and imputation, we reanalyzed models under a complete case analysis using survey weighting and replicate weighting.

Ethics and Reporting

PATH investigators obtained an National Institutes of Health certificate of confidentiality and ethical approval from the Westat institutional review board. Adult participants provided informed consent and received $35 for each wave of participation. Present analyses used fully deidentified public use files. Study reporting followed standardized guidelines (von Elm et al. 2007).

Results

Nearly 32% of the cross-sectional eligible sample (wave 3) reported performing interdental cleaning ≥7 times/wk. Interdental cleaning persisted over time. Of those indicating ≥7 times/wk at wave 3, 58% reported ≥7 times/wk at wave 4 and 94%, ≥1 times/wk. Table 1 provides sociodemographic, health, and behavioral characteristics of the cross-sectional and longitudinal samples.

Cross-sectional Associations

Interdental cleaning ≥7 times/wk versus not cleaning was associated with 1.4-times the odds of reporting excellent oral health and 0.7-times the odds of ever having experienced gum bleeding upon brushing or flossing (Table 2). Notably, gum bleeding was more common among individuals cleaning interdentally 1 to 2 or 3 to 4 times/wk versus not at all. More frequent interdental cleaning was also associated with 1.3- to 1.4-times the odds of history of tooth extraction and bone loss around the teeth, potentially reflecting reverse causation. Interdental cleaning frequency was not associated with history of loose teeth or gum disease.

Longitudinal Associations

Frequent interdental cleaning at wave 3 was positively associated with excellent self-rated oral health and inversely associated with gum bleeding approximately 1 y later, at similar magnitude to cross-sectional relationships (Table 3). However, baseline frequent interdental cleaning was not associated with any other wave 4 oral health measure. For new events only, the odds of reporting gum bleeding were 14% to 19% lower in the 2 highest categories of interdental cleaning frequency, but associations were not statistically significant (Table 4). The odds of newly reporting a tooth extraction were highest in the category of most frequent interdental cleaning but lowest in the second-most frequent category, indicating no gradient response. Interdental cleaning was not associated with newly occurring loose teeth or bone loss. The odds of newly reported gum disease were meaningfully lower with more frequent cleaning but only statistically significantly lower at the frequency of 3 to 4 times/wk.

Other Correlates of Oral Health

Both cross-sectionally (Appendix Table 1) and longitudinally (Appendix Tables 2 and 3), nearly every measure of oral health status worsened with increasing age, decreasing socioeconomic status (i.e., income and educational attainment), cigarette smoking, and diabetes, generally at association magnitudes equaling or greater than that seen for interdental cleaning. In 1 exception, reported gum bleeding was inversely associated with age and positively associated with educational attainment. Female sex was associated with better self-rated oral health but not with any specific oral health condition. Having received a professional dental cleaning was associated with better oral health on all measures, excepting baseline history of bone loss or gum disease. Cannabis use was associated with lower odds of excellent self-rated oral health and greater odds of gum bleeding and loose teeth, cross-sectionally and longitudinally. E-cigarette use was associated with worse oral health on multiple measures cross-sectionally but not longitudinally, while smokeless tobacco use was associated with worse self-rated oral health cross-sectionally and longitudinally.

Robustness Checks

Findings were largely unchanged under several alternative variable and model specifications (Appendix Tables 4–8). Collapsed into 3 category levels, interdental cleaning frequency maintained relationships with oral health outcomes of similar magnitude and direction as the 5-level specification but gained statistical power to detect inverse associations with ever-reported loose teeth (cross-sectionally) and newly reported cases of gum disease (Appendix Table 4). Adding wave 4 toothbrushing frequency to models slightly attenuated relationships between interdental cleaning and self-rated oral health and gum bleeding (Appendix Table 5).

In the collider bias assessment (Appendix Table 6), restriction on having visited a dentist in the 12 mo prior to wave 4 resulted in numeric estimates slightly more favorable for interdental cleaning (i.e., greater odds of excellent oral health, lower odds of disease outcomes) but no gain of statistical significance for previously nonsignificant findings. This suggests that available estimates for bone loss and gum disease may be slightly optimistic. Results were highly similar when obtained under a complete-case analysis and with or without balanced repeated replicate weighting (Appendix Tables 7 and 8).

Discussion

To our knowledge, this is the largest population-based longitudinal study of interdental cleaning behaviors and oral health outcomes. The findings suggest that more frequent use of dental floss or other interdental cleaning devices is associated with less gingivitis and better self-perceived oral health but not with more severe periodontal disease endpoints, including loose teeth, bone loss, and tooth loss. This conclusion must be taken in light of study limitations, most prominently the self-report of interdental cleaning and outcomes and the follow-up period lasting only 1 y.

Table 1. Wave 3 Population Characteristics: Cross-sectional and Longitudinal Samples.

	Cross-sectional Sample (n = 26,086)		Longitudinal Sample (n = 22,585)	
Characteristic	*n*	Weighted Percent	*n*	Weighted Percent
Interdental cleaning, times/wk				
None	7,734	25.0	6,584	24.7
1 to 2	4,905	17.8	4,301	18.0
3 to 4	3,593	13.8	3,121	14.0
5 to 6	2,910	11.8	2,556	11.9
≥7	6,944	31.6	6,023	31.3
Age, y				
18 to 24	8,298	13.2	7,011	13.3
25 to 34	5,706	18.7	4,935	18.9
35 to 44	3,746	16.8	3,275	16.9
45 to 54	3,464	17.7	3,066	17.4
55 to 64	2,831	16.8	2,525	17.0
≥65	2,039	16.8	1,771	16.5
Sex				
Male	12,741	47.8	10,825	47.8
Female	13,322	52.2	11,740	52.2
Race/ethnicity				
Non-Hispanic White	15,098	64.8	13,029	64.7
Non-Hispanic Black	3,886	11.5	3,393	11.5
Non-Hispanic other	2,002	8.0	1,724	8.0
Hispanic/Latinx	5,042	15.7	4,393	15.8
Annual income				
<$10,000	4,167	10.8	3,580	10.8
$10,000 to $24,999	5,079	17.9	4,362	17.7
$25,000 to $49,999	5,573	22.6	4,855	22.6
$50,000 to $99,999	5,650	27.7	4,982	28.0
≥$100,000	3,858	21.0	3,365	20.9
Education				
Below high school	3,170	9.9	2,696	9.7
High school or GED	7,772	27.2	6,599	27.1
Some college	9,165	32.2	8,006	32.3
College degree	5,893	30.8	5,225	30.8
Diabetes history				
Never	22,638	82.8	19,505	83.0
Ever	3,410	17.2	3,047	17.0
Body mass index				
<18.5	635	1.8	552	1.8
18.5 to 24.99	9,208	32.6	7,841	32.6
25 to 29.99	7,863	33.6	6,804	33.5
≥30	7,770	32.0	6,882	32.1
Recent dental cleaning				
No	9,274	31.0	7,918	30.7
Yes (past 12 mo)	16,616	69.0	14,502	69.3
Alcohol use				
None	11,596	45.6	9,970	45.0
Light	7,584	30.7	6,615	31.2
Moderate	4,208	15.3	3,684	15.3
Heavy	2,570	8.4	2,214	8.5
Cannabis use				
None	21,296	90.0	18,474	89.8
Within past 30 d	4,721	10.0	4,058	10.2
Cigarette smoking				
Never	13,056	60.0	11,635	60.6
Former	4,720	22.5	4,100	22.1
Current light	4,669	10.3	3,996	10.3
Current heavy	3,197	7.2	2,691	7.1
E-cigarette use				
Not currently	24,440	96.7	21,206	96.8
Currently	1,597	3.3	1,341	3.2
Other combustible use				
Not currently	23,891	96.4	20,755	96.5
Currently	1,693	3.6	1,420	3.5
Smokeless tobacco use				
Not currently	24,871	97.3	21,578	97.3
Currently	1,171	2.7	970	2.7

Eligible cross-sectional sample includes respondents who provided their weekly frequency of interdental cleaning, indicated ≥1 wave 3 oral health outcome measure, and reported no more than 12 teeth extracted in their life. The eligible longitudinal sample additionally reported ≥1 wave 4 oral health outcome measure. Number of respondents for some variables may be less than the total sample population due to missing data. Percentages weighted with wave 3 cross-sectional weights (cross-sectional sample) or wave 4 all-wave longitudinal weights (longitudinal sample) with balanced repeated replication.

Table 2. Cross-sectional Associations between Interdental Cleaning and Oral Health.

Outcome Measure	Weighted Percent	AOR (95% CI)
Self-rated oral health excellent		
None (reference)[a]	13.7	—
1 to 2	13.6	0.71 (0.60 to 0.84)
3 to 4	15.9	0.88 (0.73 to 1.05)
5 to 6	18.1	1.03 (0.86 to 1.23)
≥7	22.0	1.37 (1.17 to 1.59)
Ever tooth extraction		
None (reference)[a]	31.9	—
1 to 2	33.0	1.49 (1.30 to 1.71)
3 to 4	33.9	1.39 (1.20 to 1.63)
5 to 6	35.5	1.40 (1.20 to 1.64)
≥7	37.9	1.34 (1.18 to 1.52)
Ever gum bleeding		
None (reference)[a]	41.2	—
1 to 2	47.5	1.25 (1.11 to 1.39)
3 to 4	46.6	1.23 (1.08 to 1.38)
5 to 6	40.6	0.99 (0.86 to 1.13)
≥7	31.2	0.70 (0.63 to 0.78)
Ever loose teeth		
None (reference)[a]	13.3	—
1 to 2	9.5	0.98 (0.82 to 1.16)
3 to 4	10.5	1.08 (0.89 to 1.32)
5 to 6	9.5	0.98 (0.79 to 1.21)
≥7	9.5	0.95 (0.81 to 1.11)
Ever bone loss		
None (reference)[a]	7.4	—
1 to 2	9.2	1.28 (1.02 to 1.60)
3 to 4	8.7	1.10 (0.87 to 1.39)
5 to 6	11.8	1.39 (1.09 to 1.77)
≥7	13.1	1.38 (1.14 to 1.67)
Ever gum disease		
None (reference)[a]	14.6	—
1 to 2	14.8	1.03 (0.87 to 1.21)
3 to 4	15.7	1.04 (0.87 to 1.24)
5 to 6	16.8	1.05 (0.87 to 1.26)
≥7	17.1	0.96 (0.83 to 1.11)

Percentages and models weighted with wave 3 cross-sectional weights and survey weighting.
AOR, adjusted odds ratio.
[a]Interdental cleaning frequency, times per week.

Table 3. Longitudinal Associations Between Interdental Cleaning and Oral Health.

Outcome Measure	Weighted Percent	AOR (95% CI)
Self-rated oral health excellent		
None (reference)[a]	13.9	—
1 to 2	15.7	0.86 (0.72 to 1.02)
3 to 4	16.0	0.89 (0.74 to 1.07)
5 to 6	19.4	1.13 (0.93 to 1.37)
≥7	22.2	1.37 (1.17 to 1.62)
Past 12-mo tooth extraction		
None (reference)[a]	11.9	—
1 to 2	12.2	1.42 (1.17 to 1.73)
3 to 4	9.9	1.10 (0.89 to 1.37)
5 to 6	9.9	1.10 (0.87 to 1.40)
≥7	10.2	1.10 (0.92 to 1.32)
Past 12-mo gum bleeding		
None (reference)[a]	31.0	—
1 to 2	33.9	1.12 (0.99 to 1.27)
3 to 4	30.8	1.02 (0.89 to 1.18)
5 to 6	25.4	0.84 (0.72 to 0.97)
≥7	18.5	0.62 (0.54 to 0.70)
Past 12-mo loose teeth		
None (reference)[a]	6.9	—
1 to 2	4.8	0.99 (0.77 to 1.27)
3 to 4	4.9	1.01 (0.77 to 1.33)
5 to 6	5.3	1.15 (0.87 to 1.53)
≥7	4.3	0.89 (0.70 to 1.12)
Past 12-mo bone loss		
None (reference)[a]	7.7	—
1 to 2	7.6	1.20 (0.85 to 1.68)
3 to 4	6.7	0.95 (0.67 to 1.36)
5 to 6	8.1	1.14 (0.80 to 1.62)
≥7	8.7	1.15 (0.85 to 1.55)
Past 12-mo gum disease		
None (reference)[a]	7.5	—
1 to 2	6.8	1.03 (0.74 to 1.43)
3 to 4	6.7	0.97 (0.69 to 1.38)
5 to 6	7.4	1.08 (0.77 to 1.51)
≥7	6.4	0.87 (0.65 to 1.16)

Percentages and models weighted with wave 4 all-wave longitudinal weights and survey weighting.
AOR, adjusted odds ratio.
[a]Interdental cleaning frequency, times per week.

Expert and systematic reviews have uncovered few studies that examine the impact of flossing and other interdental cleaning methods on outcomes beyond plaque removal and gingival inflammation, despite their near ubiquitous recommendation in dental clinical practice. A Cochrane systematic review found 1) low-certainty evidence that flossing over and above toothbrushing reduces gingivitis in the short term, 2) very-low-certainty evidence that use of interdental brushes reduces short-term gingivitis and plaque beyond toothbrushing, and 3) a lack of trials evaluating caries and periodontal diseases (Worthington et al. 2019). An expert working group emphasized the fundamental role of dental plaque removal in preventing periodontal diseases, recommended interdental cleaning to reduce plaque and gingivitis, but noted that no existing randomized controlled trials evaluate interdental cleaning to prevent gingivitis or periodontitis around healthy individual teeth (Chapple et al. 2015).

The present results are comparable to large population-based studies featuring clinically measured outcomes. Data from Australia similarly revealed an inverse association between interdental cleaning and plaque and gingivitis but no association with clinical attachment loss (Crocombe et al. 2012). In a longitudinal study of 1,667 Finish adults, interdental cleaning was not statistically significantly associated with periodontal pocketing over 11-y follow-up (Bernabé et al. 2019). Some inconsistencies among studies may be attributable to design and measurement differences—for example, how variables defining interdental cleaning frequency and oral health outcomes are specified. Two studies examined data from the US National Health and Nutrition Examination Survey, 2011 to 2014, but with somewhat different conclusions (Cepeda et al. 2017; Marchesan et al. 2018). In one (Cepeda et al. 2017), interdental cleaning ≥1 d/wk was associated with lower prevalence of at least mild periodontal disease but with

no dose-response. The second (Marchesan et al. 2018) did note gradient responses, with more frequent interdental cleaning associated with lower prevalence of caries, tooth loss, and unfavorable periodontal profile classes. In the present study, gum bleeding was reported most often at an interdental cleaning frequency of 1 to 2 times/wk. Infrequent or improper cleaning may cause some bleeding, and individuals cleaning only periodically are perhaps more prone to notice their gingival condition than those never cleaning.

While a clear limitation, reliance on self-reported outcome measures was arguably a logistical necessity for a cohort this large. Coherence of the observed associations between oral health and age, socioeconomic status, and tobacco use supports the validity of the measures used. Previous evaluations support the utility of self-reported measures of periodontal disease but note higher specificity than sensitivity (Blicher et al. 2005; Ramos et al. 2013), suggesting that outcomes in PATH may be underreported, which, even if nondifferential, may bias results toward the null. Self-rated oral health has no obvious clinically measurable analog but may capture aspects of oral health and well-being that are meaningful for patients, including pain, function, and confidence.

Although the present results suggest mixed effectiveness of home interdental cleaning as performed in a generalizable population-based cohort, findings do not necessarily demand that dental professionals cease recommending interdental cleaning to patients. Given low cost and safety, an association with better self-rated oral health alone may justify current practice. Frequency of interproximal cleaning, as measured here, does not capture respondents' capability, technique, or method used. Regularly applied professional flossing has been shown to reduce caries risk among children, unlike flossing under unsupervised conditions (Hujoel et al. 2006). Interdental cleaning devices differ in plaque control efficacy, with studies suggesting superiority of interdental brushes over dental floss (Chapple et al. 2015; Kotsakis et al. 2018; Amarasena et al. 2019). The present study was based in the United States, where dental floss is more commonly used and recommended than other devices, and because questionnaire item wording specifically mentioned floss, we expect floss was the device that most study participants envisioned when responding. The impact of an efficacious but less commonly used device could be obscured. Appropriate use of the most effective devices with proper technique would presumably yield more compelling disease prevention. Unanswered is how to empower and motivate patients and nonpatients alike to perform effectual home plaque removal.

While study objectives related to interdental cleaning, other model covariables associated with oral health offer insight, with the caveat that such associations should be considered direct effects controlled for interdental cleaning (Westreich and Greenland 2013). We confirm a socioeconomic gradient in oral health (Singh et al. 2019). Results confirm cigarette smoking as one of the most consequential modifiable risk factors for adverse periodontal outcomes (Warnakulasuriya et al. 2010), supporting the dental profession's role in tobacco use prevention and cessation. Cannabis use was positively associated with experiencing gum bleeding and loose teeth, cross-sectionally and prospectively and independent of tobacco use, adding to evidence of oral health harms (Thomson et al. 2008; Chisini et al. 2019). E-cigarette use was positively associated with history of tooth extractions, bone loss, and gum disease but not with longitudinal outcomes. However, relatively low-use levels and strong correlations with cigarette smoking complicate the independent assessment of noncigarette tobacco use.

Among other limitations, interdental cleaning was also self-reported. Despite similar weekly frequencies as noted in other national estimates (Fleming et al. 2018), it is possible that social desirability compelled respondents to overreport their oral hygiene behaviors, which would bias results against observing a benefit. A 1-y follow-up period may be insufficient to develop advanced disease endpoints. The relatively small number of observed new events limited statistical power, although most nonsignificant associations were numerically near the null value. Unmeasured confounding is possible. Fluoride exposure and sugar consumption were not measured in the PATH Study and presumably affected tooth retention.

Table 4. Longitudinal Associations between Interdental Cleaning and Oral Health: New Events.

Outcome Measure	Weighted Percent	AOR (95% CI)
Past 12-mo tooth extraction		
None (reference)[a]	5.6	—
1 to 2	4.4	1.22 (0.88 to 1.71)
3 to 4	3.5	0.92 (0.65 to 1.31)
5 to 6	2.1	0.56 (0.37 to 0.85)
≥7	5.3	1.35 (1.01 to 1.82)
Past 12-mo gum bleeding		
None (reference)[a]	11.8	—
1 to 2	14.5	1.20 (0.96 to 1.50)
3 to 4	12.6	1.12 (0.87 to 1.43)
5 to 6	9.0	0.81 (0.62 to 1.06)
≥7	8.7	0.86 (0.69 to 1.06)
Past 12-mo loose teeth		
None (reference)[a]	3.0	—
1 to 2	2.2	1.05 (0.73 to 1.53)
3 to 4	2.3	1.13 (0.73 to 1.76)
5 to 6	2.5	1.25 (0.83 to 1.88)
≥7	2.2	1.05 (0.73 to 1.51)
Past 12-mo bone loss		
None (reference)[a]	4.3	—
1 to 2	5.1	1.57 (1.02 to 2.43)
3 to 4	3.4	0.96 (0.58 to 1.58)
5 to 6	4.0	1.18 (0.73 to 1.89)
≥7	4.1	1.14 (0.76 to 1.71)
Past 12-mo gum disease		
None (reference)[a]	4.2	—
1 to 2	2.9	0.91 (0.54 to 1.53)
3 to 4	1.7	0.53 (0.28 to 0.98)
5 to 6	1.7	0.56 (0.30 to 1.04)
≥7	2.1	0.69 (0.41 to 1.16)

Percentages and models weighted with wave 4 all-wave longitudinal weights and survey weighting. Analyses restricted to respondents reporting no history of the outcome at wave 3.
AOR, adjusted odds ratio.
[a]Interdental cleaning frequency, times per week.

Likewise, diet, physical activity, and other general health variables were not measured or not included in analysis. We speculate that adding such model covariables would unlikely generate results more favorable to interdental cleaning than observed. Some outcome measures were limited only to respondents who recently visited a dentist, raising the prospect of selection bias. However, a collider bias assessment suggested that such bias may be small.

Conclusion

In this large, nationally representative longitudinal study, frequent interdental cleaning was associated with better self-perceived oral health and less gingival bleeding but not with measures of more advanced periodontal disease states. In the absence of large-scale randomized controlled trials, prospective epidemiologic studies provide critical evidence in evaluating potential health benefits of interdental cleaning. However, the present findings must be weighed against inherent limitations, including self-reported exposures and outcomes, a short follow-up period, and possible unmeasured confounding, as well as recognition that population-based studies assess interdental cleaning behaviors as practiced and reported, not necessarily interdental plaque removal itself. Despite limitations, the present study does not provide evidence that interdental cleaning prevents advanced periodontal disease and tooth loss.

Author Contributions

B.W. Chaffee, contributed to conception, design, data analysis, and interpretation, drafted and critically revised the manuscript; D. Persai, M.V. Vora, contributed to conception, design, and data interpretation, critically revised the manuscript. All authors gave final approval and agree to be accountable for all aspects of the work.

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