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Spurious associations in oral epidemiological research: the case of dental flossing and obesity

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Abstract

Background: Individuals with increased oral health awareness may also have increased general health awareness, and vice versa. Such associations between oral and general health awareness has the potential to induce spurious associations in oral epidemiological research.

Objective: To assess the extent to which oral self-care patterns and general health awareness are confounded, we investigated the association between flossing and obesity, two lifestyle factors that are unlikely to be causally related.

Methods: A cross-sectional study of 1497 individuals presenting for an initial periodontal exam by the specialist. Self-reported flossing behaviors and body mass index (BMI) categories were related using logistic regression models.

Results: After adjustment for confounding variables, lack of daily flossing was associated in a dose-dependent way with morbid obesity (odds ratio (OR), 20.3; 95% confidence interval (CI), 2.7–154.0), obesity (OR, 2.1; 95% CI, 1.5–2.9), and being overweight (OR, 1.7; 95% CI, 1.3–2.2). When restricting to never smokers, a significant relationship between obesity and lack of flossing remained.

Conclusion: The strong associations between two causally unrelated oral and general lifestyle characteristics indicate that simplistic epidemiologic methodology is unlikely to provide insights into causal mechanisms of oral diseases or oral-systemic relationships.

Key words: flossing; obesity; self-care; systemic health

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Correlations between oral self-care patterns and general health lifestyles can make it challenging to understand what causes oral diseases, and what causes oral diseases to be associated with systemic diseases. For instance, a close correlation between healthy eating habits and oral hygiene can make it challenging to determine whether, ultimately, good oral health is the consequence of an ''apple-a-day'' diet, a ''brush-after-every-meal'' habit, a combination of both, or due to some other unmeasured general or oral health awareness factor that is closely correlated to both the ''apple-a-day'' diet and meticulous oral self-care patterns. Similarly, close associations between oral habits such as flossing and general health awareness habits such never smoking can make it difficult to determine whether flossing can extend your life by 6.4 years, as one doctor claims (Roizen 1999), or whether it is the never-smoking habit that is correlated with flossing that actually extends life-span.

As early as 1979 flossing has been evaluated as a marker of medical health protective behaviors (Harris & Guten Mar 1979). Flossing has been related to general lifestyle habits such as alcohol consumption (Toneatto & Binik 1990), health seeking behavior such as preventive dental maintenance visits (Ojima et al. 2005) and preventive medical care (Toneatto & Binik 1990), diabetes (Moore et al. 2001; Siudikiene et al. 2005), and body mass index (Toneatto & Binik 1990). We are not aware of studies that have reported associations between aspects of general health awareness and oral-self care patterns for individuals with periodontitis. As periodontitis has been associated with scores of systemic diseases, the association between self-care behaviors such as flossing and general health characteristics such as body weight has the poten-

tial to confound associations. The goal of this study was to report on the association between the frequency of flossing and obesity among patients visiting the periodontist for an initial exam.

Materials and Methods

A longitudinal cohort study was initiated to examine the association between periodontal treatment utilization patterns and tooth loss. A total of 1497 individuals were recruited between July 2003 and July 2004. These individuals presented for a comprehensive initial examination by a periodontist signed the informed consent form and mailed back a questionnaire including questions related to height, weight, flossing, brushing, and smoking behaviors. Probing data were extracted from the probing charts submitted by the periodontal specialist to the insurance company.

The question related to flossing was: ''During the last year, typically, how frequently did you floss your teeth?'' Four answers were provided: ''once or more per day'', ''2–3 times per week'', ''4–6 times per week'', and ''less than once per week''. Participants were also queried with respect to their height, weight, and smoking behavior. For the latter, a box was available to indicate whether an individual never smoked. Body mass index (BMI) was calculated from self-reported height and weight and classified as morbidly obese (BMI $\geqslant$ 40), obese (BMI $\geqslant$ 30–$<$40), overweight (BMI $\geqslant$ 25–$<$30), normal weight (BMI $>$ 18.5–$<$25), and underweight (BMI $\leqslant$ 18.5).

The association between the likelihood of daily flossing and obesity was evaluated using generalized linear models with a logit link and a binomial error function. Odds ratios (ORs) and 95% confidence intervals (CIs) are reported. The analyses were adjusted for potentially confounding variables such as age, gender, diabetic status, smoking history.

Results

A total of 1497 patients visited a periodontal specialist and consented to participate in the study. Of those who provided flossing information ($n = 1483$ or 99%), 37% reported daily flossing, 10% reported flossing four to five times a week, 27% reported flossing two to three times a week, and 26% reported flossing less than once a week (Table 1). The BMI among these patients that visited a periodontal specialist was as follows: 36% ($n = 529$) of the patients had a weight classified as normal, 41% ($n = 602$) were classified as overweight, 21% ($n = 307$) were classified as obese, and 2% ($n = 23$) of the patients were morbidly obese (data not shown). Twenty-one patients did not report height and/or weight.

Table 1. Flossing frequency and general and oral health awareness characteristics among patients presenting for specialist care

	Self-reported flossing behavior ($n = 1497$)				
	Daily ($n = 549$)	4–6 times per week ($n = 143$)	2–3 times per week ($n = 405$)	<1 per week ($n = 381$)	Missing, *n* (%)
Age	55.4 (8.7)	53.7 (7.6)	53.8 (7.5)	55.2 (8.0)	101 (6.7%)
% female	59.5%	56.6%	53.4%	35.9%	51 (3.4%)
Tooth count	24.8 (4.8)	24.5 (5.5)	25.1 (4.7)	24.9 (4.4)	105 (7.0%)
Teeth with pockets >5 mm	5.2 (4.8)	5.2 (4.7)	6.2 (5.7)	7.6 (6.4)	105 (7.0%)
Height (m)	1.69(0.10)	1.72(0.10)	1.71 (0.10)	1.74 (0.10)	7 (.5%)
Weight (kg)	74.8 (16.8)	79.3 (17.9)	81.0 (18.1)	85.3 (18.2)	18 (1.2%)
BMI	25.9 (4.6)	26.7 (4.4)	27.7 (5.4)	28.2 (5.3)	21 (1.4%)
Diabetes	9.3%	6.2%	10.8%	9.9%	31 (2.1%)
Regular care*	46.0%	43.4%	33.7%	31.4%	22 (1.5%)
OHQOL†	17.8(18.1)	16.8 (16.7)	18.8 (18.6)	18.4 (17.9)	18 (1.2%)
% Low self-assessed oral health‡	32.1%	9.0%	26.8%	32.1%	29 (1.9%)
% Never-smokers	40.5%	34.5%	30.3%	30.1%	15 (1.0%)

*Regular care indicates that surveyed individual reported affirmative to the following question: 'Have you regularly seen a specialist for gum disease prior to your most recent appointments?'

†OHQOL, Oral Health Related Quality of Life. The number presented can range between 0 (perfect OHQOL) and 100 (abominable OHQOL). The score is calculated based on six questions related to the impact of oral health on eating, pain, avoiding going out, relaxing, feeling denture discomfort, and self-conscious or worried due to oral health problems.

‡Low self-assessed oral health indicates that surveyed person answered ''fair or poor'' to the following question: ''How would you describe the health of your teeth and gums?''

Flossing frequency was significantly related to several oral and general health characteristics (Table 1). Flossing frequency was significantly related to age, gender, BMI index, and smoking status, as detailed below. Flossing was also significantly related to the number of teeth, the number of teeth with at least one pocket deeper than 5 mm, the self-perceived oral health, and the oral-heath related quality of life score. Females, when compared with males, had a 71% increased odds for reporting daily flossing (OR = 1.71; 95% CI, 1.37–2.1). Never-smokers were 30% more likely to be a daily flosser than former-smokers (OR = 1.38; 95% CI, 1.08–1.75). Never-smokers were 89% more likely to be a daily flosser than current smokers (OR = 1.89; 95% CI, 1.41–2.54). Individuals who did report a prior visit to the periodontist were 62% more likely to be daily flossers than individuals who did not report a prior history of care (OR = 1.62; 95% CI, 1.30–2.01). Neither diabetes nor the numbers of teeth present were significantly related to the likelihood of daily flossing.

The likelihood for daily flossing decreased with increasing obesity in a dose-dependent manner (Table 2). Unadjusted for confounding variables, morbid obesity was most strongly associated with a lack of daily flossing (OR, 19.25; 95% CI, 2.58–143.86), followed by obesity (OR, 2.16; 95% CI, 1.60–2.92), and being overweight (OR, 1.68; 95% CI, 1.32–2.14). Adjustment for the sociodemographic variables age and gender, and further adjustment for diabetes, smoking status, and a history of prior periodontal care did not substantially alter this association. Neither did adjustment for the number of teeth or the number of teeth with periodontal pockets deeper than 5 mm change the obesity–flossing association. When the analysis was restricted to never-smokers, being overweight increased the risk for non-daily flossing 130% (OR, 2.30; 95% CI, 1.45–3.63) and being obese increased the odds for non-daily flossing by 169% (OR, 1.69; 95% CI, 1.53–4.72).

Discussion

''Lose 5 pounds? Floss more?'' was reported on the cover of a popular sports magazine (Peruzzi 2006). Such headlines reflect the general awareness among non-medical people that decisions to improve lifestyles are often complex and involve more than just the habit to pick up flossing. Habits such as seat belt use, smoking, and preventive medical visits correlate (Hofer & Katz 1996). The findings of this study provide specific evidence that one particular marker of self-care behavior, absence of or lessened daily flossing, correlates to obesity among periodontal patients. This study indicated that such associations could occur in a dose-dependent fashion; the higher the BMI index, the lower the likelihood for daily flossing.

These findings reinforce that teasing out the proper associations within oral epidemiological research is a complex process. In particular, the strong flossing–obesity association we observed reminds us that two general hypotheses need careful evaluation in oral epidemiological research. First, good oral health may be the result of factors related to general health awareness rather than oral self-care patterns. Second, good systemic health may be the result of positive general health awareness (as exemplified by the absence of obesity), rather than good oral self-care behaviours.

Other studies have identified similar associations between oral and general health awareness. In one Canadian study, 75% of individuals with a low index of oral health behaviours also had a low index of general health behaviours (Payne & Locker 1996). In other studies, specific oral behaviors such as dental flossing has been associated with factors such as less alcohol use, more regular medical check-ups, less body fat (Toneatto & Binik 1990), and lower prevalence of diabetes (Siudikiene et al. 2005). These studies provide a glimpse of the complexity of oral disease epidemiology. For instance, the association of regular flossing with increased risk for diabetes can suggest that flossing prevents diabetes, that diabetes causes a decrease in flossing, or that lack of flossing and diabetes are linked in a non-causal way. Daily flossing may be no more than a marker of positive general health awareness. Disentangling these different causal pathways is challenging, but necessary to develop an accurate understanding of the relationships of risk factors to disease.

In extremis, the flossing–obesity link could be interpreted as causal; the ''floss-or-die'' motto could be extended to include a ''floss-and-lose-weight-slogan''. Just as for other oral-systemic disease links, biological plausibility mechanisms could be identified. Lack of flossing is associated with anaerobic interproximal situations that create reservoirs for *Helicobacter pylori* infections (Dowsett & Kowolik 2003). *H. pylori* infections might promote the release from gastric A-like cells of ghrelin a peptide hormone that potently stimulates appetite (Isomoto et al. 2005). In addition, the between-meal release of interproximal food might stimulate taste receptors, which could promote feeding. Daily flossing interferes with these biological pathways. This biological plausibility, the dose–response curve, the strong and consistent floss–BMI associations does, in our opinion, *not* provide evidence to plead for flossing intervention trials, but provide a reminder of the strong correlations between general and oral health habits.

The flossing–obesity association indicates that oral disease epidemiology is challenging. First, it may be difficult to determine whether oral diseases are caused by oral health behaviours such as flossing or general health behaviours such as diet. While it is well accepted that diseases such as oral cancer are predominantly determined by general health risk factors such as smoking and alcohol use, the role of general health habits in dental diseases such as periodontitis has often remained unrecognized. Textbooks on clinical periodontics have been written where the begin-all, end-all focused predominantly on accretions on teeth, and the role of the host in terms of effects on periodontal health has been virtually ignored (Lindhe 1985). The close non-flossing–obesity link indicates that one could easily be misled into believing that good oral hygiene completely prevents periodontal diseases, while possibly general health awareness factors could determine periodontal disease prevalence to a signifcant extent.

Second, the flossing–obesity link also indicates that oral-systemic disease research is challenging. While currently the epidemiological evidence in support of periodontitis-systemic disease associations is weak to start with, some hints of small associations are being interpreted seriously as providing sufficient evidence to initiate randomized-controlled trials. Conditions such as gingivitis could be expected to be associated with cardiovascular disease because of the flossing–obesity association, rather than a direct causal link between flossing and cardiovascular disease. Health awareness has been a major confounder in epidemiological studies ranging from the role of hormone replacement therapy in post-menopausal women (Enserink 2002) to the well-known effects of

Table 2. Relative odds for non-daily flossing associated with BMI categories defined by World Health Organization

	Crude OR (95% CI) ($n = 1464$)	Adjusted OR (95% CI)			
		+age, gender* ($n = 1458$)	+diabetes, smoking status† ($n = 1405$)	+# teeth and pockets >5 mm, prior periodontal care‡ ($n = 1303$)	Restricted to never-smokers§ ($n = 450$)
Underweight	1.00 (0.36–2.80)	0.87 (0.31–2.47)	0.95 (0.33–2.76)	0.82 (0.27–2.49)	1.31 (0.23–7.64)
Overweight	1.68 (1.32–2.14)	1.54 (1.20–1.98)	1.61 (1.24–2.09)	1.62 (1.23–2.13)	2.30 (1.45–3.63)
Obese	2.16 (1.60–2.92)	2.04 (1.50–2.78)	2.16 (1.56–2.98)	2.21 (1.58–3.11)	2.69 (1.53–4.72)
Morbidly obese	19.25 (2.58–143.86)	22.54 (3.00–169.35)	22.7 (3.00–172.87)	21.56 (2.81–164.86)	–

*Age categories: 35–49, 49–54, 54–60, >60; gender: male, female, unknown.

†Diabetes (yes/no); smoking status (former, current, never).

‡Prior periodontal care (yes/no); # Teeth, number of teeth (1–32); # pockets >5mm: Number of teeth with pockets deeper than 5 mm (0–28).

§Never-smokers are those individuals indicating never to have smoked.

healthy volunteer bias (Thomson et al. 2005). Simplistic epidemiological approaches to the dental-systemic disease associations can be expected to lead to meaningless associations. Efforts to control for the effect of general health awareness may include limiting analysis to never-smokers, establishing cohorts of individuals with similar health awareness such as nurses or health professionals who can be assumed to have a more homogenous health awareness, and strict control for factors such as socioeconomic status that are linked to health awareness-related behaviors.

In conclusion, a strong dose–response curve between lack of flossing and BMI was observed. The higher the BMI, the less likely an individual was to floss. This study confirms other findings that oral and general health awareness are correlated and has implications both for understanding the cause of oral diseases and the reasons why oral and systemic diseases can be correlated. While it has been common to assume that only oral factors cause oral diseases and that oral diseases cause systemic diseases, the alternative hypothesis deserves more consideration; both oral and systemic diseases are strongly influenced by general health awareness factors.

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Clinical Significance

Health awareness characteristics such as smoking habits, diet choices, physical exercise routines, medical preventive actions, oral self-care habits, and seat-belt use can be correlated. These correlations make it difficult for the clinician and the researcher to determine whether good oral health is the result of oral self-care patterns or the result of positive general health behaviors, or whether poor systemic health is the result of poor oral self-care patterns or poor lifestyles. The finding of this study, that irregular flossing is associated with obesity independent of smoking, reminds us about the close association between general and oral health awareness.