

Association of flossing/inter-dental cleaning and periodontitis in adults

M. Soledad Cepeda¹  | Rachel Weinstein¹ | Clair Blacketer¹ | Michael C. Lynch²

¹Department of Epidemiology, Janssen Research & Development, LLC, Titusville, NJ, USA

²Global Scientific Engagement - Oral Care, Johnson & Johnson Consumer Inc., Skillman, NJ, USA

Correspondence

M. Soledad Cepeda, Senior Director Epidemiology, Janssen Research & Development, Titusville, NJ, USA.
Email: scepeda@its.jnj.com

Funding information

Johnson & Johnson Consumer Inc., is the maker of LISTERINE® floss. All authors are Johnson & Johnson employees and are shareholders of Johnson & Johnson.

Abstract

Aim: Assess the association of flossing with periodontitis.

Materials and Methods: This was a cross-sectional study using the National Health and Nutrition Examination Survey (NHANES) years 2011-2014. We used three categories of flossing: 0-1, 2-4 and ≥ 5 days in the past week and the CDC definition of periodontitis. We calculated odds ratios controlling for age, gender, smoking, drinking, income and dentist visits.

Results: A total of 6939 adult subjects were included, 35% flossed ≤ 1 time a week, and 40% had periodontitis. After adjustment, the odds of periodontitis were 17% lower for subjects who flossed >1 time a week than for subjects who flossed less often (odds ratio=0.83, 95% CI 0.72-0.97). A dose response was not observed. Men were twice as likely as women to have periodontitis. Younger subjects, non-smokers and subjects with the highest incomes had lower odds of having periodontitis.

Conclusions: Flossing was associated with a modestly lower prevalence of periodontitis. Older age, being male, smoking, low income and less frequent dental visits were associated with a higher prevalence of periodontitis. Flossing 2-4 days a week could be as beneficial as flossing more frequently. This is a cross-sectional study so a causal relation between flossing and periodontitis cannot be established.

KEYWORDS

cross-sectional study, flossing, inter-dental cleaning, national health and nutrition examination survey, periodontitis

1 | BACKGROUND

Good oral hygiene practices are widely considered important to maintaining good oral health, and flossing has long been considered an indispensable part of an effective oral hygiene routine. Dental plaque is a bacterial biofilm which causes chronic gingivitis and periodontitis (Hasan & Palmer, 2014), and flossing removes plaque or controls its accumulation (Chapple et al., 2015). Periodontitis is a common chronic condition characterized by gingival inflammation of the supporting tissues around the teeth (Savage, Eaton, Moles, & Needleman, 2009). It affects approximately 45% of adults in the

USA (Eke et al., 2015), and it is a major cause of tooth loss (Chapple et al., 2015).

Even though flossing has been considered to be important to oral health, systematic reviews and meta-analyses of randomized controlled trials found that flossing is associated with only a small reduction in plaque and gingivitis (Berchier, Slot, Haps, & Van der Weijden, 2008; Salzer, Slot, Van der Weijden, & Dorfer, 2015). The individual studies in the meta-analyses were small, with a total number of subjects in the flossing groups of fewer than 600 (Sambunjak et al., 2011).

The National Health and Nutrition Examination Survey (NHANES) is a national research programme that collects health information

This is an open access article under the terms of the Creative Commons Attribution-NonCommercial License, which permits use, distribution and reproduction in any medium, provided the original work is properly cited and is not used for commercial purposes.

© 2017 The Authors. *Journal of Clinical Periodontology* Published by John Wiley & Sons Ltd.

from a representative sample of the US population through interviews and medical and oral examinations (CDC, 2015, National Center for Health Statistics, 2015). It asks thousands of people questions about the frequency of flossing and includes standardized periodontal examinations conducted by dentists, making the diagnosis of periodontitis reliable. Therefore, NHANES is a reasonable source to understand the association between flossing and periodontal disease.

1.1 | Objective

The objective of this study was to assess the association of flossing with periodontitis.

2 | MATERIALS AND METHODS

2.1 | Study design

This was a cross-sectional study.

2.2 | Source

The data source was the NHANES years 2011 to 2014. We selected these years because NHANES implemented the same protocol for assessing periodontitis during that time.

2.3 | Inclusion criteria

Subjects 30 and older who underwent a periodontal examination and responded to the question about frequency of flossing were included. Only those subjects 30 years of age and older were subject to a periodontal examination, per the NHANES specifications.

2.4 | Exposure

The exposure was flossing. We based the exposure on the response to the question (OHQ.870) in NHANES (EKE, Page, Wei, Thornton-Evans, & Genco, 2012).

Aside from brushing [your] teeth with a toothbrush, in the last seven days, how many days did you use dental floss or any other device to clean between your teeth?

Three categories were created from the responses: from 0–1 day, 2–4 days and 5 or more days in the past week. We categorized flossing a priori to avoid making assumptions about a linear association between flossing and the prevalence of periodontitis.

2.5 | Outcome

The outcome was periodontitis. We used the CDC definition of periodontitis (Eke et al., 2012). This definition is based on measurements of attachment loss and pocket depth and includes mild, moderate or severe periodontitis.

Clinical Relevance

Scientific rationale for the study: Meta-analyses of short-duration trials found that daily flossing produced a small reduction in plaque and gingivitis. We conducted a population-based study using NHANES data to assess the association of flossing with periodontitis. NHANES collects information from a representative sample of the US population.

Principal findings: Flossing was associated with a modestly lower prevalence of periodontitis. No dose response was observed. Older age, being male, smoking and low-income were associated with periodontitis.

Practical implications: Flossing 2–4 days a week may be as beneficial as flossing more frequently. This cross-sectional study cannot establish a causal relation.

2.6 | Potential confounder variables

The development of periodontitis has been associated with increasing age, being male, low economic status, frequency of visits to the dentist, smoking and alcohol consumption (Eke et al., 2015) (Pitiphat, Merchant, Rimm, & Joshipura, 2003). Thus, we included these variables as potential confounders.

Age was classified a priori into three categories: 30–49, 50–64 and 65 or older.

Socioeconomic status was assessed through income. Income was grouped into four categories: very low, low, middle and high income, based on the participant's response to the annual household income question. Very low income was defined as annual income <\$15,000, low income as annual income between \$15,000 and \$34,999, middle income as annual income between \$35,000 and \$74,999 and high income as annual income \$75,000 or higher.

Participants were classified as never, former or current smokers. Current smokers were those subjects reporting having smoked at least 100 cigarettes in their lifetime and currently smoking every day or some days. Former smokers were those subjects reporting having smoked at least 100 cigarettes in their lifetime but who do not currently smoke.

For alcohol use, participants were classified as never, former and current drinkers. Current drinkers were those subjects reporting at least 12 drinks in their lifetime and who have had at least 1 drink in the past 12 months. Former drinkers were those subjects who reported drinking at least 12 drinks in their lifetime and no drinks in the past 12 months.

Frequency of visits to the dentist is also a potential confounder. We categorized time since last visit to the dentist into three categories: visited a dentist within the past year, visited a dentist >1 to ≤3 years ago, or visited > 3 years ago or never have visited a dentist. This is based on the response to question OHQ.030: *About how long has it been since you last visited a dentist?*

2.7 | Analysis

To assess the association of flossing with periodontitis, we built a logistic regression and calculated unadjusted and adjusted odds ratios (ORs).

The outcome in the logistic regression model was the presence or absence of periodontitis and the model included the categories of flossing frequency, age, gender, smoking, drinking, income and frequency of visits to the dentist as potential confounding variables. We also reported the adjusted odds ratios for these variables. For variables with missing data, a separate category was created. Therefore, the model accounts for the missing data and for its potential effect on the outcome.

To correctly account for the complex survey design, the analyses included the primary sampling unit variable (sdmvsu) for variance estimation, the pseudo-stratum variable (sdmvsra) as the stratification variable and Mobile Examination Center (wtmec) weights (Mirel et al., 2013). NHANES provides sample weights to be used in conjunction

with the data to allow analysts to produce estimates that are representative of the US population. When combining multiple cycles of data, as in this study, the 2-year weights must be adjusted. Using the estimation procedure guidelines provided by NHANES, we multiplied the weight variable by 1/2, because we included two survey periods. (Mirel et al., 2013).

2.8 | Ad hoc analyses

To address the question of the association of no flossing at all with periodontitis, we created two flossing categories: no flossing at all in the previous week and flossing at least once in the previous week. We followed the same procedures as with the main analyses, and we report unadjusted and adjusted odds ratios.

STATA SE version 14.2 was used to conduct the analyses.

Each one of NHANES surveys has been approved by the NCHS Research Ethics Review Board. NHANES releases anonymized coded survey data to the public. These are the data used in the present study.

Characteristic	Flossing 0–1 days a week N (column %)	Flossing 2–4 days a week N (column %)	Flossing ≥5 days a week N (column %)
Number of subjects (row %)	2642 (35)	1597 (25)	2700 (40)
Number of men	1519 (59)	762 (48)	1113 (40)
Age			
Number of subjects between 30 and 49 years of age	1281 (54)	855 (54)	1126 (42)
Number of subjects between 50 and 64 years of age	785 (30)	494 (33)	927 (36)
Number of subjects ≥65 years of age	576 (17)	248 (13)	647 (22)
^a Smoking behaviour			
Number of current smoker	620 (22)	262 (16)	394 (14)
Number of former smoker	636 (24)	381 (25)	699 (28)
Number of never smokers	1386 (54)	954 (57)	1602 (57)
^a Drinking behaviour			
Number of current drinkers	1594 (67)	1083 (75)	1690 (70)
Number of former drinkers	470 (16)	214 (10)	428 (14)
Number of never drinkers	360 (10)	183 (9)	396 (11)
^a Income			
Lowest income	623 (16)	239 (10)	439 (11)
Low income	622 (20)	300 (15)	536 (15)
Middle income	679 (28)	439 (27)	750 (31)
Upper income	590 (32)	562 (46)	857 (40)
^a Dental visits			
>3 years ago or never visit a dentist	443 (15)	125 (7)	162 (5)
Visited dentist >1 year and ≤ 3 years	307 (11)	162 (10)	201 (6)
Visited dentist within the last year	576 (26)	428 (28)	914 (38)

TABLE 1 Characteristics of the subjects by flossing frequency

^aNumbers do not add to 100% because of missing data.

TABLE 2 Association of flossing with periodontitis

	No periodontitis N (%)	Periodontitis N (%)	Unadjusted OR (95% CI)	Adjusted OR (95% CI)
Flossing 0–1 days a week	1149 (31)	1493 (42)	Reference	Reference
Flossing 2–4 days a week	932 (27)	665 (21)	0.56 (0.49–0.65)	0.79 (0.66–0.94)
Flossing ≥5 days a week	1484 (42)	1216 (37)	0.64 (0.57–0.73)	0.83 (0.72–0.97)

3 | RESULTS

Of the 7661 subjects who responded to the flossing question, 6939 had periodontal examination data. Of these subjects, 35% flossed no more than once in the past week. Men, younger subjects, current smokers, subjects with the lowest incomes and subjects who rarely visited a dentist flossed less frequently than their counterparts. There was not a clear pattern of flossing frequency for current drinkers (Table 1).

3.1 | Association of flossing with periodontitis

Overall, 40% of the subjects had periodontitis. A higher percentage of subjects who flossed no more than once a week had periodontitis compared with subjects who flossed more often (Table 2). Unadjusted results show that compared with no flossing, people who flossed more than once a week had lower odds of having periodontitis (Table 2). No dose response was observed, meaning that the magnitude of the protective effect did not increase with greater flossing frequency.

After adjustment, the association of flossing with periodontitis remains statistically significant; however, the magnitude of the association decreased. The odds of having periodontitis were 17% lower for someone who flosses more than once a week. As with the unadjusted results, a dose response was not observed (Table 2).

3.2 | Association of age, gender, smoking and drinking status, income and visits to the dentist with periodontitis

After adjustment for established risk factors and flossing, we found that men are twice as likely as women to have periodontitis. Compared with subjects age 30–49, older subjects had higher odds of having periodontitis. For example, subjects 65 or older had three times the odds (Table 3).

Non-smokers and even former smokers had lower odds of having periodontitis than current smokers. The odds are 69% lower for non-smokers than current smokers (Table 3).

Compared with current drinkers, former drinkers had higher odds of having periodontitis (Table 3).

The odds of having periodontitis were substantially lower in subjects with the highest incomes (70% lower) than the lowest income. Visiting a dentist within the last year was associated with lower odds of having periodontitis, compared with subjects who never or rarely visit a dentist (Table 3).

3.3 | Ad hoc findings

The analyses in which the reference category was no flossing at all (instead of flossing no more than once a week) provided similar results to the main analyses. Compared with no flossing at all, flossing 1 or more days a week reduced the odds of having periodontitis by 23% (Table 4).

4 | DISCUSSION

This large, population-based, observational study found that flossing was associated with a lower prevalence of periodontitis; however, the magnitude of the association was modest. The associations of age, gender, smoking, frequency of dental visits and income with periodontitis were substantially stronger than the protective association observed for flossing. Nonetheless, the benefit of flossing was seen, in addition to the known benefit of toothbrushing. This is a cross-sectional study so it is difficult to argue for a causal relation between

TABLE 3 Association of age, gender, smoking and drinking status, income and visits to the dentist with periodontitis

Characteristic	Odds ratio (95% confidence interval)
Women	Reference
Men	2.04 (1.84–2.26)
Subjects between 30 and 49 years of age	Reference
Subjects between 50 and 64 years of age	2.04 (1.65–2.51)
Subjects ≥65 years of age	3.21 (2.58–4.01)
Current smoker	Reference
Former smokers	0.40 (0.31–0.51)
Never smokers	0.31 (0.26–0.40)
Current drinkers	Reference
Former drinkers	1.42 (1.14–1.78)
Never drinkers	1.29 (0.92–1.81)
Lowest income	Reference
Low income	0.90 (0.69–1.17)
Middle income	0.63 (0.49–0.80)
Upper income	0.30 (0.25–0.37)
>3 years ago or never visit a dentist	Reference
Visited dentist >1 year and ≤ 3 years	0.61 (0.43–0.87)
Visited dentist within the last year	0.42 (0.31–0.55)

	No periodontitis N (%)	Periodontitis N (%)	Unadjusted OR (95% CI)	Adjusted OR (95% CI)
No flossing	861 (40)	1296 (60)	Reference	Reference
Flossing ≥ 1 day a week	2703 (57)	2078 (43)	0.54 (0.49–0.60)	0.77 (0.67–0.87)

TABLE 4 Association of no flossing at all with periodontitis

flossing and periodontitis; therefore, we can only state that there is a negative association.

A large percentage (35%) of the US population does not floss or does not floss frequently. Others have found low a frequency of flossing and that the frequency of flossing increases as income or education increases (Chen & Stone, 1983). The observed benefit of flossing did not show a dose response, suggesting that flossing 2–4 days a week could be enough to protect against periodontitis when combined with brushing.

One possible hypothesis for these findings is that removal of interproximal plaque on a daily basis may not be necessary to mitigate disease initiation and/or progression. The composition of the plaque microflora changes over time due to a series of complex interactions, termed microbial succession (Marsh, Martin, Lewis, & Williams, 2009). Mechanical disruption of the inter-proximal plaque as infrequent as every few days may be sufficient to halt the microbial succession process that leads to a more mature plaque, one that is widely understood to be associated with inflammation and disease initiation.

Systematic reviews of published, randomized clinical trials have found a small benefit of flossing on reducing plaque and gingivitis (Sambunjak et al., 2011). These published studies were limited in that they were most often short term (4 weeks or less), had small sample sizes and were therefore unable to assess any potential long-term benefit. Our study, which is based on observational data, found a modest association between flossing and prevalence of periodontitis, which takes longer to develop and is more consequential than gingivitis (Pihlstrom, Michalowicz, & Johnson, 2005).

This is an observational study, and therefore, remaining bias could explain the study results (Hujoel, Cunha-Cruz, & Kressin, 2006). Indeed, we observed that controlling for the effect of potential confounders reduced the magnitude of the association of flossing with periodontitis.

Frequency of flossing was based on self-reporting, and self-reported answers may be inaccurate. However, the question on flossing asked about the frequency of flossing in the last 7 days, making it likely that participants remembered the frequency of flossing accurately, so misclassification may not be substantial in this survey. The question we used to assess flossing included not only dental floss but also any other device used to clean between teeth. Studies have shown that the efficacy of flossing and inter-dental cleaning is different at least in terms of reducing gingivitis (Salzer et al., 2015), so it would have been ideal if we could have assessed them separately.

Flossing requires a proper technique; in this study, we know how often subjects floss, but we do not know how well they do it. The benefit of flossing could depend on how well it is done (Lang, Ronis, & Farghaly, 1995). The lack of dose response we observed could be explained by subjects not flossing adequately.

This is the largest study to date that assesses the association of flossing with periodontitis. All the subjects went through an oral health examination by dentists following similar protocols and intense training prior to the beginning of the survey (Eke et al., 2015). The standardization of the measurements of the outcome minimizes the risk of misclassification of the outcome, thereby increasing the validity of the findings. Furthermore, the participants are representative of the US population, so the study findings can be generalized to the population aged 30 and older. Lastly, this study was based on publicly available data and used a standard definition of periodontitis; therefore, the findings of this study can be replicated.

In summary, we found that flossing is associated with a modestly lower prevalence of periodontitis. Older age, being male, smoking, infrequent visits to the dentist and low income are associated with higher prevalence of periodontitis. Flossing 2–4 days a week could be as beneficial as flossing more frequently.

ACKNOWLEDGEMENTS

Dr. Paul I. Eke from the Division of Population Health, National Center for Chronic Disease Prevention and Health Promotion, Centers for Disease Control and Prevention graciously provided us a file with periodontitis already defined using the CDC definition. Therefore, we did not have to do the coding from the multiple variables to define whether a subject had periodontitis.

Ajit Londhe from the Department of Epidemiology at Janssen Research and Development provided a meticulous quality check on the code used for this project and helped ensure we used the correct variables in NHANES to assess periodontitis.

CONFLICT OF INTEREST

Johnson & Johnson Consumer, Inc., is the maker of LISTERINE® floss. All authors are Johnson & Johnson employees and are shareholders of Johnson & Johnson.

REFERENCES

- Berchier, C. E., Slot, D. E., Haps, S., & Van der Weijden, G. A. (2008). The efficacy of dental floss in addition to a toothbrush on plaque and parameters of gingival inflammation: A systematic review. *International Journal of Dental Hygiene*, 6, 265–279. <https://doi.org/10.1111/j.1601-5037.2008.00336.x>
- CDC (2015). *National health and nutrition examination survey*. Centers for Disease Control and Prevention.
- Chapple, I. L., Van der Weijden, F., Doerfer, C., Herrera, D., Shapira, L., Polak, D., ... Graziani, F. (2015). Primary prevention of periodontitis: Managing gingivitis. *Journal of Clinical Periodontology*, 42(Suppl 16), S71–S76. <https://doi.org/10.1111/jcpe.12366>

- Chen, M. S., & Stone, D. B. (1983). Toothbrushing, flossing, and dental visits in relation to socioeconomic characteristics of white American families. *Community Dentistry and Oral Epidemiology*, 11, 325–332.
- Eke, P. I., Dye, B. A., Wei, L., Slade, G. D., Thornton-Evans, G. O., Borgnakke, W. S., ... Genco, R. J. (2015). Update on Prevalence of Periodontitis in Adults in the United States: NHANES 2009 to 2012. *Journal of Periodontology*, 86, 611–622. <https://doi.org/10.1902/jop.2015.140520>
- Eke, P. I., Page, R. C., Wei, L., Thornton-Evans, G., & Genco, R. J. (2012). Update of the case definitions for population-based surveillance of periodontitis. *Journal of Periodontology*, 83, 1449–1454. <https://doi.org/10.1902/jop.2012.110664>
- Hasan, A., & Palmer, R. M. (2014). A clinical guide to periodontology: Pathology of periodontal disease. *British Dental Journal*, 216, 457–461. <https://doi.org/10.1038/sj.bdj.2014.299>
- Hujoel, P. P., Cunha-Cruz, J., & Kressin, N. R. (2006). Spurious associations in oral epidemiological research: The case of dental flossing and obesity. *Journal of Clinical Periodontology*, 33, 520–523. <https://doi.org/10.1111/j.1600-051X.2006.00954.x>
- Lang, W. P., Ronis, D. L., & Farghaly, M. M. (1995). Preventive behaviors as correlates of periodontal health status. *Journal of Public Health Dentistry*, 55, 10–17.
- Marsh, P. M., Martin, M. V., Lewis, M., & Williams, D. (2009). Chapter 5: Dental plaque. In P. Marsh, M. V. Martin (Eds.), *Oral microbiology* (5th ed. pp. 74–102). London: Churchill Livingstone.
- Mirel, L. M., Mohadjer, L. K., Dohrmann, S. M., Clark, J., Burt, V. L., Johnson, C. L., & Curtin, L. R. (2013). National Health and Nutrition Examination Survey: Estimation procedures, 2007–2010. *Vital and Health Statistics. Series 2, Data Evaluation and Methods Research*, 2, 1–17.
- National Center for Health Statistics (2015). *National Health and Nutrition Examination Survey, 2013–2014*.
- Pihlstrom, B. L., Michalowicz, B. S., & Johnson, N. W. (2005). Periodontal diseases. *Lancet*, 366, 1809–1820. [https://doi.org/10.1016/s0140-6736\(05\)67728-8](https://doi.org/10.1016/s0140-6736(05)67728-8)
- Pitiphat, W., Merchant, A. T., Rimm, E. B., & Josphipura, K. J. (2003). Alcohol consumption increases periodontitis risk. *Journal of Dental Research*, 82, 509–513. <https://doi.org/10.1177/154405910308200704>
- Salzer, S., Slot, D. E., Van der Weijden, F. A., & Dorfer, C. E. (2015). Efficacy of inter-dental mechanical plaque control in managing gingivitis—a meta-review. *Journal of Clinical Periodontology*, 42(Suppl 16), S92–S105. <https://doi.org/10.1111/jcpe.12363>
- Sambunjak, D., Nickerson, J. W., Poklepovic, T., Johnson, T. M., Imai, P., Tugwell, P., & Worthington, H. V. (2011). Flossing for the management of periodontal diseases and dental caries in adults. *Cochrane Database Systematic Review*, CD008829. <https://doi.org/10.1002/14651858.cd008829.pub2>
- Savage, A., Eaton, K. A., Moles, D. R., & Needleman, I. (2009). A systematic review of definitions of periodontitis and methods that have been used to identify this disease. *Journal of Clinical Periodontology*, 36, 458–467. <https://doi.org/10.1111/j.1600-051X.2009.01408.x>

How to cite this article: Cepeda MS, Weinstein R, Blacketer C, Lynch MC. Association of flossing/inter-dental cleaning and periodontitis in adults. *J Clin Periodontol*. 2017;44:866–871. <https://doi.org/10.1111/jcpe.12765>