Research Article

Cross-Sectional Association between the Number of Missing Teeth and Cardiovascular Disease among Adults Aged 50 or Older: BRFSS 2010

R. Constance Wiener1 and Usha Sambamoorthi2

1 Department of Dental Practice and Rural Health, School of Dentistry, and Department of Epidemiology, School of Public Health, Robert C. Byrd Health Sciences Center, West Virginia University, P.O. Box 9448, Morgantown, WV 26506, USA
2 Department of Pharmaceutical Systems and Policy, Robert C. Byrd Health Sciences Center, West Virginia University, School of Pharmacy, P.O. Box 9510, Morgantown, WV 26506-9510, USA

Correspondence should be addressed to R. Constance Wiener; rwiener2@hsc.wvu.edu

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Objective. The relationship between oral health and cardiovascular disease is an emerging area of research. The objective of the current study is to evaluate the association of cardiovascular disease and the number of missing teeth as a risk indicator.

Methods. Cross-sectional study design with data on 275,424 respondents aged 50 or older from the 2010 Behavioral Risk Factor Surveillance System survey was used. The dependent variable was self-reported cardiovascular disease. The association between the number of missing teeth and cardiovascular disease was analyzed with multivariable logistic regression. The regression was adjusted for sex, race/ethnicity, age, education, income, dental visits, smoking status, physical activity, and body mass index.

Results. In our study sample, 9.9% reported edentulism. Cardiovascular prevalence rates for those with edentulism were 25.4% and for those without any missing teeth were 7.5%. Respondents who reported edentulism teeth were more likely to report cardiovascular disease (AOR = 1.85, 95% CI = 1.71, 2.01).

Conclusion. There was an independent association between the number of missing teeth and cardiovascular disease even after controlling for a comprehensive set of risk factors. These findings highlight the need to explore the potential role the number of missing teeth have in the risk of cardiovascular disease among older adults.

1. Introduction

The lifetime incident risk for cardiovascular disease is very high. It is estimated at 66% for men and 50% for women at the age of 40. Numerous studies have reported that healthy lifestyle practices (maintaining a normal blood pressure, having a normal body mass index, limiting alcohol use, and smoking cessation or never smoking) and good psychological health (such as stress management, and social support) can reduce the risk of cardiovascular disease [1–5]. Additionally, poor oral health has been recognized as a potential risk factor to developing cardiovascular disease due to its systemic impacts. However, a recent review conducted by the American Heart Association concluded that, while there is an association between periodontal disease and atherosclerotic vascular disease, there may not be a causative relationship. The review also identified knowledge gaps in the understanding of oral health and atherosclerotic vascular disease [6]. The knowledge gaps included limited understanding of the relationship of the number of missing teeth and cardiovascular disease.

Understanding the association between the number of missing teeth and the risk of cardiovascular disease is important because oral health interventions may improve cardiovascular health. Biological mechanisms proposed for an association of the number of missing teeth and cardiovascular disease include (1) inflammation, (2) infection, and (3) diet and nutrition [7]. For the inflammation hypothesis, chronic oral infection (as periodontal diseases leading to the number of missing teeth) contributes to systemic inflammation...
2. Materials and Methods

2.1. Study Design. This study is a secondary data analysis of public access data which does not require IRB approval. It used a retrospective, observational, and cross-sectional design using data from the annual 2010 Behavioral Risk Factor Surveillance System (BRFSS) survey of Americans.

2.2. Data Source. The researchers at the Centers for Disease Control and Prevention (CDC) in conjunction with the state health departments actively survey the population who are 18 years or older in a nationally representative study, the BRFSS survey, for health behaviors and health risk factors. The survey-developers from the CDC and state health department created probability samples of households with a multistage cluster design to provide a nationally representative sample with a complex design. The interviews are conducted over the telephone using random-digit dialing in blocks of telephone numbers to create the probability sample of households. The sampling design is detailed elsewhere [16]. There were 451,075 participants in the 2010 BRFSS survey. The eligible participants had no missing data on the presence or absence of cardiovascular disease, had no missing data on the number of missing teeth that they had, were 50 years and older, and had completed the interview. There were 6,541 participants who had missing data on the number of missing teeth that they had. The final sample size was 275,424.

2.3. Dependent Variable. The dependent variable was the presence of cardiovascular disease (yes/no). This was determined by an affirmative response to either of the posed questions in the BRFSS survey: “Has a doctor, nurse, or other health professional ever told you that you had a heart attack, also called a myocardial infarction?” “Has a doctor, nurse, or other health professional ever told you that you had angina or coronary heart disease?”

2.4. Key Independent Variable: The Number of Missing Teeth. The number of missing teeth was derived from self-report. The posed question and statements were “How many of your permanent teeth have been removed because of tooth decay or gum disease? Include teeth lost to infection, but do not include teeth lost for other reasons, such as injury or orthodontics. If wisdom teeth are removed because of tooth decay or gum disease, they should be included in the count for lost teeth.” The possible responses were “none,” “1 to 5,” “6 or more, but not all,” and “all.” We maintained the categories presented in the BRFSS. The threshold of five missing teeth has been shown to reduce misclassification of missing teeth extracted for orthodontics or the third molar extractions [9].

2.5. Other Independent Variables. Other independent variables or factors were demographic characteristics—sex (women, men); race/ethnicity (non-Hispanic Blacks and others, Hispanic, and non-Hispanic White); age (50–59 years, 60–69 years, and 70 years and above); socioeconomic characteristics—education (less than high school, some college or technical school, high school, graduate of
Results

The sample included 275,424 participants. The majority were female (53.8%), non-Hispanic white (77.5%), and between the ages of 50 and 59 (42.9%). Most had some college, technical school, or above (61.4%). Data are not reported in tabular form. Income above $50,000 was reported by 46.1%, and income below $15,000 was reported by 10.6%. There were 71.5% of the participants who reported having had a dental visit within the year; 50% reported never smoking; 72.1% of the participants who reported having had a dental visit within the previous year, smoking, physical activity, and BMI categories on the likelihood of cardiovascular disease are displayed in Table 2. For adults who lost 1 to 5 teeth compared to adults who had no missing teeth, the AOR for cardiovascular disease was 1.27 (95% CI, 1.19, 1.35). The AOR for cardiovascular disease for the participants with 6 or more missing teeth, but not all missing teeth was 1.65 (95% CI, 1.54, 1.77), and the AOR for cardiovascular disease for the participants who had all of their teeth missing was 1.85 (95% CI, 1.71, 2.01). We also observed that adults who visited the dentist were less likely to report cardiovascular disease compared to those who did not visit dentists in the past year. The AOR was 0.88; 95% CI = 0.83, 0.93.

In our study, other risk factors were also associated with increased risk of cardiovascular disease. Adults who were women, old age, overweight, obese, and being a current smoker were more likely to report cardiovascular disease compared with adults who were men, belonged to younger age-group, had normal BMI, and reported never smoking. Adults who reported regular physical activity and had a greater income had a reduced likelihood of cardiovascular disease compared to adults without regular physical activity and lower income groups.

Discussion

This study indicated a significant independent relationship between edentulism and cardiovascular disease in a large population of older adults aged 50 years or older in the US as compared with individuals who had no missing teeth. We also observed increased likelihood of cardiovascular disease among those with some missing teeth. Older adults with 1 to 5 missing teeth and greater than 6 missing teeth, but not all teeth missing, were more likely to report presence of cardiovascular disease as compared with older adults who had no missing teeth. Findings from the current study are consistent with those conducted in Northern Finland, Brazil, and Scotland and other studies conducted in the US [12–15].

The increased risk of cardiovascular disease and the number of missing teeth can be attributed to many factors including nutritional problems. The number of missing teeth has been associated with chewing difficulty [7, 9], and chewing difficulty has been associated with dietary changes, self-reported nutritional problems, and decreasing the range of food eaten [17]. Heart-healthy diets have been researched and have been found to lower blood pressure in controlled feeding studies, for example, the Dietary Approaches to Stop Hypertension (DASH) and the three Optimal Macronutrient Intake Trial to Prevent Heart Disease (OmniHeart) diets (higher carbohydrate, higher protein, higher unsaturated fat) [18]. In a randomized controlled study of two modified Mediterranean diets and a low fat control diet (in which participants did not have controlled feeding), results indicated that a Mediterranean diet supplemented with extra-virgin
Table 1: Characteristics of the 275,424 study participants according to the number of missing teeth in the behavioral risk factor surveillance system, 2010 (N, weighted%).

| No missing teeth | 1-5 missing teeth | 6 or more, but not all missing teeth | All teeth missing | Chi-square P value |
|------------------|-------------------|-------------------------------------|------------------|--------------------|
|                  | N | wt% | N | wt% | N | wt% | N | wt% |
| Participants     | 90023 | 35.2 | 97745 | 36.5 | 53718 | 18.4 | 33938 | 9.9 | P < 0.0001 |
| Cardiovascular disease | 7063 | 2.6 | 11828 | 4.3 | 10415 | 3.5 | 8484 | 2.5 | P < 0.0001 |
| No CV disease     | 82960 | 32.6 | 85917 | 32.2 | 43303 | 14.8 | 25454 | 7.4 |
| Female            | 57151 | 19.2 | 59852 | 18.9 | 33411 | 10.0 | 22212 | 5.7 | P < 0.0001 |
| Male              | 32872 | 16.0 | 37893 | 17.6 | 20307 | 8.4 | 11726 | 4.2 |
| NHW               | 78872 | 29.6 | 80194 | 27.5 | 41231 | 13.0 | 26916 | 7.4 |
| NHB               | 2801 | 1.4 | 6681 | 3.3 | 6265 | 2.6 | 3256 | 1.2 |
| Hispanic          | 3786 | 2.7 | 5494 | 3.9 | 2844 | 1.7 | 1519 | 0.7 |
| Other             | 3568 | 1.6 | 4213 | 1.8 | 2640 | 1.0 | 1602 | 0.5 |
| 50–59             | 40555 | 19.5 | 32666 | 15.9 | 12544 | 5.5 | 5134 | 2.0 |
| 60–69             | 28650 | 9.5 | 33429 | 11.3 | 17770 | 5.8 | 10105 | 2.9 |
| 70 and above      | 20818 | 6.3 | 31650 | 9.4 | 23404 | 7.0 | 18699 | 4.9 |
| Less than HS      | 3256 | 1.5 | 6410 | 3.0 | 7948 | 2.9 | 9144 | 2.7 |
| High school       | 18957 | 6.9 | 30798 | 10.7 | 21178 | 6.9 | 14550 | 4.2 |
| Some college      | 23365 | 8.6 | 27670 | 9.1 | 14392 | 4.8 | 7114 | 2.0 |
| College           | 44260 | 18.3 | 32687 | 12.8 | 10085 | 3.8 | 3024 | 1.0 |
| <$15,000          | 4491 | 1.8 | 8227 | 3.3 | 9201 | 3.2 | 8061 | 2.4 |
| $15K to <$25K     | 8981 | 3.3 | 15069 | 5.6 | 12457 | 4.5 | 9741 | 3.2 |
| $25K to <$35K     | 7836 | 2.9 | 11872 | 4.4 | 7428 | 2.9 | 4162 | 1.5 |
| $35K to <$50K     | 12131 | 4.8 | 14988 | 6.0 | 7216 | 3.0 | 3207 | 1.2 |
| $50K+             | 44262 | 22.7 | 33898 | 17.3 | 9896 | 4.9 | 2866 | 1.2 |
| Dental visit      | 74667 | 29.4 | 76174 | 28.2 | 33882 | 11.6 | 7042 | 2.3 |
| No dental visit   | 15199 | 5.9 | 21411 | 8.4 | 19649 | 6.7 | 26185 | 7.5 |
| Smoker            | 7046 | 2.8 | 11504 | 4.6 | 10440 | 3.8 | 8225 | 2.6 |
| Past smoker       | 28202 | 11.0 | 35200 | 13.3 | 22432 | 7.8 | 14490 | 4.2 |
| Never smoker      | 54127 | 21.4 | 50472 | 18.7 | 20526 | 6.8 | 11019 | 3.1 |
| Diabetes          | 11415 | 4.4 | 17737 | 6.6 | 13382 | 4.8 | 9573 | 2.8 |
| No diabetes       | 78542 | 30.8 | 80289 | 29.9 | 40285 | 13.6 | 24319 | 7.0 |
| PA                | 71328 | 28.3 | 71300 | 26.9 | 33562 | 11.6 | 18410 | 5.4 |
| No PA             | 18606 | 7.0 | 26320 | 9.7 | 20079 | 6.7 | 15461 | 4.5 |
| BMI < 25          | 32816 | 12.5 | 29891 | 10.9 | 15293 | 5.1 | 10711 | 3.1 |
| BMI 25 to <30     | 33171 | 14.0 | 36594 | 14.6 | 19239 | 6.9 | 11785 | 3.7 |
| BMI 30+           | 20434 | 8.6 | 27587 | 11.0 | 17416 | 6.4 | 10172 | 3.1 |

NHW: non-Hispanic White; NHB: non-Hispanic Black; HS: high school; K: 1000; Dental visit: dental visit within the year; PA: physical activity; BMI: body mass index.

Olive oil or nuts was associated with better survival, which was similar to those results of the Women’s Health Initiative Dietary Modification Trial [4]. These diets and others stress the importance of a variety of foods, particularly fruits and vegetables, and the avoidance of highly processed foods, particularly refined carbohydrates as being strongly supported in cardiovascular health maintenance [19]. Eating fruits and vegetables is problematic for many people, particularly people who have many missing teeth. The number of missing teeth may therefore increase the risk for several systemic diseases, including cardiovascular disease [20].

In addition to diet and nutrition, inflammation and infection have been proposed for the association between the number of missing teeth and cardiovascular disease [7]. Previous research has indicated that chronic infection, as seen in chronic periodontal diseases, has systemic consequences in increasing inflammatory cytokines and coagulation factors that are associated with cardiovascular disease which are thought to remain increased even after tooth extraction [8]. Another potential mechanism involves oral bacteria (or their products) entering the vascular system to create transient bacteremias which potentiate cardiovascular disease [8].
Table 2: Adjusted odds ratios (AOR) and the 95% confidence intervals according to cardiovascular diseases for the variables in the final logistic regression analysis behavioral risk factor surveillance system, 2010.

|                      | AOR (CI)          | P value  |
|----------------------|-------------------|----------|
| **Missing teeth**    |                   |          |
| 1–5 extracted-teeth versus no missing teeth | 1.27 (1.19, 1.35) | <0.0001 |
| >6 extracted-teeth versus no missing teeth  | 1.65 (1.54, 1.77) | <0.0001 |
| Edentulism versus no missing teeth            | 1.85 (1.71, 2.01) | <0.0001 |
| **Sex**              |                   |          |
| Female versus male                                       | 0.48 (0.46, 0.50) | <0.0001 |
| **Race/ethnicity** |                   |          |
| Non-Hispanic Black versus non-Hispanic White            | 0.87 (0.80, 0.95) | 0.0018  |
| Hispanic versus non-Hispanic White                    | 0.84 (0.75, 0.94) | 0.0025  |
| Other versus non-Hispanic White                       | 1.17 (1.03, 1.32) | 0.0132  |
| **Age**              |                   |          |
| 60–69 versus 50–59                                        | 1.89 (1.78, 2.02) | <0.0001 |
| 70 and older versus 50–59                               | 3.32 (3.12, 3.54) | <0.0001 |
| **Education**      |                   |          |
| HS versus less than HS                                   | 0.96 (0.89, 1.04) | 0.3278  |
| Some college/technical versus less than HS              | 1.06 (0.97, 1.15) | 0.2101  |
| College/technical degree versus less than HS            | 0.95 (0.87, 1.04) | 0.2717  |
| **Income**        |                   |          |
| $15000–25000 versus less than $15000                      | 0.83 (0.77, 0.89) | <0.0001 |
| $25000–35000 versus less than $15000                      | 0.65 (0.60, 0.71) | <0.0001 |
| $35000–50000 versus less than $15000                      | 0.61 (0.56, 0.67) | <0.0001 |
| Greater than $50000 versus less than $15000               | 0.49 (0.45, 0.53) | <0.0001 |
| **Dental visit within the year**                       |                   |          |
| Yes versus no visit                                        | 0.88 (0.83, 0.93) | <0.0001 |
| **Smoking**       |                   |          |
| Current smoker versus never smoker                        | 1.46 (1.36, 1.57) | <0.0001 |
| Former smoker versus never smoker                         | 1.42 (1.35, 1.49) | <0.0001 |
| **Physical activity**                                   |                   |          |
| Yes versus no                                             | 0.75 (0.71, 0.79) | <0.0001 |
| **Body Mass Index**                                      |                   |          |
| Overweight versus normal                                 | 1.25 (1.18, 1.32) | <0.0001 |
| Obese versus normal                                       | 1.66 (1.57, 1.76) | <0.0001 |

An interesting finding of our study is the reduced risk of cardiovascular disease among those who had visited the dentist compared to those who had not visited dentists in the past year. Additional study is needed to determine if periodontal care reduces systemic inflammation and its potential cardiovascular effects. Although studies have documented the importance of preventive oral health among those with teeth, our study findings highlight the importance of the number of missing teeth as an important risk factor in the health care of older adults. Improved oral health is critical; however, many older adults find financial barriers (no dental insurance and inability to pay) as access to care barriers [21].

This study has a number of strong points. It uses recent nationally representative data from a large, national, US data source. A comprehensive list of risk factors was included in the logistic regression model to address residual confounding. However, our study findings need to be interpreted in the light of its limitations. As a characteristic of all cross-sectional study designs, although associations can be determined, temporal associations and causality cannot be verified. This study is also based on self-reported data, with the potential of misclassification.

Despite the limitations, our study extends previous epidemiological research by highlighting the association between edentulism and cardiovascular disease [9]. The current study adds to the growing but nascent literature on the association between the number of missing teeth and cardiovascular disease. Additionally, the study findings have clinical implications. The significant association between the number of missing teeth and cardiovascular disease in an older population suggests (1) the importance of maintaining healthy teeth and gingival tissue into old age and (2) the potential usefulness of physician oral screening for the number of missing teeth and vigilance for cardiovascular disease in the presence of many lost teeth.
Conflict of Interests

The authors declare that there is no conflict of interests regarding the publication of this paper.

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