Tooth Loss and Stroke: Results from the Behavioral Risk Factor Surveillance System, 2010

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Abstract

Purpose: Strokes are common events of significant morbidity and mortality. Poor oral conditions may share or exacerbate pathways that lead to stroke.

Methods: This study was a cross-sectional study of 410,939 participants from the 2010 Behavioral Risk Factor Surveillance System. Stroke was defined as the participant's response (yes/no) to the survey's question, "Has a doctor, nurse or other health professional ever told you that you had a stroke?" The definition for tooth loss was based upon participant's response to the survey's question, "How many of your permanent teeth have been removed because of tooth decay or gum disease?" Descriptive, Chi Square and logistic regression analyses were conducted. Other variables that are known etiologic factors were also included in the analysis.

Results: The participants with increasing numbers of teeth lost had increasing adjusted odds ratios for stroke independent of the other factors. In adjusted logistic regression analysis, the participants who had 1 to 5 missing teeth had an adjusted odds ratio (AOR) of 1.29 (95% Confidence Interval (CI): 1.17, 1.42), participants who had 6 or more, but not all missing teeth had an AOR of 1.68 (95% CI: 1.50, 1.88), and participants who were edentulous had an AOR of 1.86 (95% CI: 1.63, 2.11).

Conclusion: Evidence from this cross-sectional study indicates that tooth loss had a potential, although weak positive association as an independent factor in multivariable analysis with stroke.

Keywords: stroke, cerebrovascular accident, cerebral vascular accidents, edentulous, tooth loss, missing teeth

This study supports the NDHRA priority area, **Clinical Dental Hygiene Care:** Investigate the links between oral and systemic health.

Introduction

Strokes (cerebral vascular accidents, cerebral infarctions, cerebrovascular ischemia) were among the 5 leading causes of death in the U.S. in 2010.[1] Of the 1,796,620 deaths of older (>65 years) Americans in 2010, 6% were attributed to stroke.[1] There are more than 795,000 strokes each year with 610,000 occurring as first-time strokes.[2]

Poor outcomes are often associated with stroke – 15% of people having a stroke die, and stroke is the leading cause of adult disability.[3] Disabilities may include paralysis, cognitive impairment, repeated strokes, seizures, falls, pain, depression, confusion, and difficulty or inability to speak.[4] In addition to the physical burden, the financial burden has been estimated at $54 billion per year.[5]

Delayed care, symptom denial, or lack of knowledge of symptoms have resulted in poor patient outcomes.[6] The 5 sudden warning signs are:[7-9]

1. Confusion/speech problems
2. Headache
3. Dizziness
4. Blurry vision
5. Numbness/weakness

Risk factors for stroke are a history of high blood pressure, hyperlipidemia, smoking, diabetes, atrial fibrillation, heavy alcohol use, heart disease, previous stroke or transient ischemic attacks.[6]

Oral health and periodontal disease in particular has been studied as a risk factor for atherosclerotic cerebrocardiovascular diseases, including stroke. A positive association has been reported by some authors,[10-13] while no association/non-significant association has been reported by others.[14,15] Additionally, positive, though not necessarily strong, association was determined in 2 systematic reviews,[16,17] a review of literature[18] and 2 consensus reports/scientific statements (with no current evidence of causation, or that periodontal intervention will prevent atherosclerotic vascular disease).[19,20]

Similarly, poor oral health, in terms of fewer teeth, has also been associated with atherosclerotic cerebrovascular diseases, including ischemic stroke.[13,21-23] In a prospective study of 41,380 older male professionals with no cardiovascular disease at baseline, after 12 years, the men who had fewer

than 25 teeth at baseline had a hazard ratio of 1.57 as compared with men who had 25 or more teeth at baseline.[21] In a cross-sectional study of 4 U.S. communities with 1,491 edentulous adults and 6,436 dentate adults, stroke/transient ischemic attack was prevalent in 22.5% of the edentulous adults and they had an odds ratio of 1.4 as compared with the quartile of dentate participants with the least extent of attachment loss.[22] Similarly, a study of 358 patients (those having had a stroke - n=181, those discharged after other medical conditions - n=177) showed an association of tooth loss and early occurrence of stroke.[23] However, a prospective study of 7,674 adults ages 20 to 89 years, followed for 12 years, indicated that participants who had fewer than 10 teeth, as compared with participants who had greater than 25 teeth, had a 7-fold increase of coronary heart disease, but there was no dose relationship with stroke.[10] And a study of 392 community dwelling older adults in Finland indicated people with a large number of teeth had a slight, non-significant increase in the likelihood of ischemic stroke as compared with the people who had fewer teeth.[24]

Dental diseases may be categorized as lifestyle-related diseases.[23] As such, people at risk of stroke may have poorer oral health than people at lower risk of stroke. It has not been fully established that there is a relationship between tooth loss and stroke. If such an association exists, it may be a simple way of identifying otherwise healthy individuals with increased risk of stroke and may be useful in stroke prevention.[13] The purpose of this study is to determine whether an association between increasing tooth loss and non-fatal stroke exists.

Methods and Materials

The data for this study were obtained from the publically available results of the 2010 Behavioral Risk Factor Surveillance System (BRFSS). Starting in 1984, the BRFSS is a yearly survey providing health related data through a cross-sectional telephone survey.[25] The BRFSS is state-based with assistance from the Centers for Disease Control and Prevention (CDC). Each month, the states' researchers contact non-institutionalized adults, ≥18 years, to ask about health risk, injuries, prevention and access to health care.[25] The interviewers use a standardized questionnaire and computer-assisted telephone interviewing computer files.[26] An interview with at least age, race and sex is considered complete.[26] A second contact is made for individuals who initially refuse to respond to the survey, unless the person is verbally abusive.[26] The Behavioral Surveillance Branch of the CDC created a complex survey design to adequately represent race/ethnicity. The survey is de-identified and is available to the public. Each year, there are more than 350,000 adults who respond to the survey.[26] For 2010, the BRFSS data set had 451,075 records.[27]

The dependent variable/outcome of interest was the participant's response to the question, "Has a doctor, nurse, or other health professional ever told you that you had a stroke?"[28] The possible responses were yes, no and don't know/not sure. The main independent variable/exposure was the participant's response to the question, "How many of your permanent teeth have been removed because of tooth decay or gum disease?"[28] The participants were asked to, "Include teeth lost to infection, but do not include teeth lost for other reasons, such as injury or orthodontics." The potential responses were none, 1 to 5, ≥6 but not all, all and don't know/not sure.

Other variables of interest relevant in studying stroke were sex (male v. female), race/ethnicity (Hispanic, non-Hispanic Black, non-Hispanic other v. non-Hispanic White), age in years (30 to 44, 50 to 59, 60 to 69, ≥70 v. 18 to 29), education (less than high school, high school completion, some college or technical school v. college or technical school completion), health insurance (not insured v. insured), smoking status (current, occasional, former v. never smokers), physical activity (no v. yes), dental visits within the previous year (no v. yes), heavy drinking (for men more than 2 drinks per day, for women more than 1 drink per day) (yes v. no), diabetes (yes v. no), and body mass index (BMI) (25 to <30, ≥30 v. less than 25).[6]

Data were analyzed using SAS 9.3 (Cary, NC). Bivariate association between stroke and variables of interest were tested using the Chi-Square test. Model development used multivariable logistic analysis, specifically using Proc Surveylogic in SAS 9.3, and weighting to accommodate the complex multilevel sampling design using the variables: STSTR (stratum), PSU (primary sampling unit) and FINALWT (weight). Participants were excluded if there were missing, refused or did not know responses to the variables of interest (missing teeth and stroke). The final sample size was 410,139. A priori statistical significance was defined as $p<0.05$.

Results

Table I includes the descriptive characteristics of the study population in addition to the Chi Square analyses. There were 51.6% women, 69.4% non-Hispanic whites, 9.6% non-Hispanic blacks and 14% were Hispanic. A total of 17.1% of respon-

Table I: Chi Square Analysis for Stroke and Variables of Interest - Behavioral Risk Factor Surveillance System, 2010 (n=410,139)

	Stroke Column		No Stroke Column		Total	Weighted Percentages*
	n	Weighted Percentages*	n	Weighted Percentages*		
Number of missing teeth (Significance<0.0001)**						
No missing teeth	3,557	23.9	176,294	55.6	179,851	54.8
1 to 5 missing teeth	5,184	31.2	129,008	30.3	134,192	30.3
6 or more/not all	4,748	25.8	56,253	9.7	61,001	10.1
All teeth are missing	4,058	19.2	31,837	4.4	35,895	4.8
Sex (Sig=0.0014)**						
Women	10,947	53.9	245,766	51.5	256,713	51.6
Men	6,600	46.1	147,626	48.5	154,226	48.4
Race/Ethnicity (Significance<0.0001)**						
Non-Hispanic White	13,645	70.4	313,725	69.4	327,370	69.4
Non-Hispanic Black	1,889	13.0	30,502	9.5	32,391	9.6
Hispanic	904	9.8	27,974	14.2	28,878	14.0
Non-Hispanic Other	1,109	6.7	21,191	7.0	22,300	7.0
Age (in years) (Significance<0.0001)**						
18 to 29	106	2.5	23,978	17.6	24,084	17.1
30 to 49	1,403	16.0	108,520	40.9	109923	40.2
50 to 59	2,771	19.3	87,620	18.2	90,391	18.3
60 to 69	4,629	22.5	84,853	12.3	89,482	12.6
70 and above	8,535	39.7	85,778	11.1	94,313	11.8
Education (Significance<0.0001)**						
Less than High School	2,995	17.8	34,360	9.6	37,355	9.8
High School	6,210	34.1	114,480	27.1	120,690	27.3
Some college, tech	4,639	26.3	105,196	26.4	109,835	26.4
Degree or above	3,661	21.8	138,543	36.9	142,204	36.5
Income level (Significance<0.0001)**						
<$15,000	3,791	223.0	38,326	10.2	42,117	10.5
$15,000 to <$25,000	4,399	27.7	59,020	15.1	63,419	15.5
$25,000 to <$35,000	1,979	12.2	41,081	10.3	43,060	10.4
$35,000 to <$50,000	1,883	13.8	52,650	13.7	54,533	13.7
$50,000 and above	2,686	23.4	151,767	50.7	154,453	49.9

*Weighted percentages were obtained to control for complex sample design, therefore division of individual cell sizes by the total sample will not reflect weighted percentages. Significant group differences were tested by Chi Square statistics.
**Rao-Scott Chi-Square p-values

dents were 18 to 29 years of age, 40.2% were 30 to 49, and 11.8% were ≥70 years. The education level of respondents was 62.9% who had some college (technical school or more), 26% had incomes <$25,000 and 14.8% were not insured. There were 83.1% reporting being a former or never smoker, and 35.8% had a BMI <25, 36.2% had a BMI of 25 to <30 at 36.2%, and 28% had a BMI of ≥30. The majority of participants were physically active outside of work (76%), had dental visits within the previous year (70%), were not heavy drinkers (95.1%) and did not have diabetes (88.7%).

Table I also provides the Chi Square analyses of the variables of interest versus the report of a history of stroke. Statistically significant differences in relation to stroke history existed among the number of missing teeth, sex, race/ethnicity, age, education, income, health insurance, smoking status, BMI, physical activity level, dental visits within the previous year, heavy drinking and diabetes.

The results of the logistic regression analyses are presented in Table II. The unadjusted odds ratios in support of an association between missing teeth and stroke were 2.40 (95% Confidence Interval (CI) 2.21, 2.60, p<0.0001) for 1 to 5 missing teeth, 6.22 (95% CI: 5.72, 6.77, p<0.0001)

Table I: Chi Square Analysis for Stroke and Variables of Interest - Behavioral Risk Factor Surveillance System, 2010 (n=410,139) (continued)

	Stroke Column		No Stroke Column		Total	Weighted Percentages*
	n	Weighted Percentages*	n	Weighted Percentages*		
Health Insurance						
Insured	16,324	89.9	351,011	85.0	367,335	85.2
Not insured	1,180	10.1	41,512	15.0	42,692	14.8
Smoking (Significance<0.0001)**						
Current	3,376	21.7	60,730	16.8	64,106	16.9
Former	6,764	37.6	117,792	24.5	124,556	24.9
Never	7,294	40.7	212,521	58.7	219,815	58.2
BMI (Significance<0.0001)**						
<25	5,343	30.3	132,054	36.0	137,397	35.8
25 to 30	6,067	36.4	138,255	36.2	144,322	36.2
>30	5,576	33.3	106,965	27.8	112,541	28.0
Physical Activity (Significance<0.0001)**						
Yes	9,874	57.8	290,152	76.5	300,026	76.0
No	7,639	42.2	102,811	23.5	110,450	24.0
Dental Visits (Significance<0.0001)**						
Dental visits within year	9,644	55.8	276,966	70.5	286,610	70.0
No visits within year	7,771	44.2	225,056	29.5	122,827	30.0
Heavy Drinking (Significance<0.0001)**						
Yes	523	3.3	18,223	5.0	187,46	4.9
No	16,754	96.7	367,832	95.0	384,586	95.1
Diabetes (Significance<0.0001)**						
Yes	5,698	32.4	55,799	10.7	61,497	11.3
No	11,821	67.6	33,7300	89.3	349,121	88.7

* Weighted percentages were obtained to control for complex sample design, therefore division of individual cell sizes by the total sample will not reflect weighted percentages. Significant group differences were tested by Chi-square statistics.
**Rao-Scott Chi-Square p-values

for ≥6 missing teeth but not all missing teeth, and 10.20 (95% CI: 9.27. 11.01, p<0.0001) for edentulism compared with the referent group of no missing teeth as the referent.

Results of the multivariable logistic regression are also in Table II. The model was controlled for sex, race/ethnicity (Hispanics, non-Hispanic blacks, non-Hispanic others v. non-Hispanic whites), age (30 to 44, 50 to 59, 60 to 69, ≥70 v. 18 to 29), education (less than high school, high school, some college or technical school v. graduate of college or technical school or above), income level (<$15,000, $15,000 to <$25,000, $25,000 to <35,000, $35,000 to <$50,000 v. $50,000 and above), health insurance (not insured v. insured), smoking status (current, occasional, former v. never), dental visits within the previous year (no v. yes), physical activity (no v. yes), heavy drinking (for men more than 2 drinks per day, for women more than 1 drink per day) (yes v. no), diabetes (yes v. no), and BMI (25 to <30, >30 v. <25). The adjusted odds ratios were 1.29 (95% CI: 1.17, 1.42; p<0.0001) for 1 to 5 missing teeth, 1.68 (95% CI: 1.50, 1.88, p<0.0001) for 6 or more but not all missing teeth, and 1.86 (95% CI: 1.63, 2.11, p<0.0001) for edentulism compared with the referent group of no missing teeth.

Discussion

This study indicated that, in an adjusted logistic regression analysis, there remains a significant independent relationship of missing teeth and stroke. Participants who had 1 to 5 missing teeth had an adjusted odds ratio of 1.29, participants with ≥6 missing teeth but not all missing teeth had an adjusted odds ratio of 1.68, and participants who were edentulous had an adjusted odds ratio of 1.86 as compared with participants who did not have any missing teeth. These results support findings of other studies that increasing tooth loss is associ-

Table II: Odds Ratios and Adjusted Odds Ratios for Stroke from Logistic Regression on Number of Missing Teeth - Behavioral Risk Factor Surveillance System, 2010

Unadjusted	Odds Ratio	95% Confidence Interval	Significance
Number of teeth removed			
None 1 to 5 6 or more; not all All	1.00 2.40 6.22 10.10	- [2.21, 2.60] [5.72, 6.77] [9.27, 11.01]	<0.0001
Adjusted	Adjusted Odds Ratio	95% Confidence Interval	Significance
Number of teeth removed			
None (Reference Group) 1 to 5 6 or more; not all All	1 1.29 1.68 1.86	- [1.17, 1.42] [1.50, 1.88] [1.63, 2.11]	<0.0001

The adjusted model is controlled for: sex (male v. female), race/ethnicity (Hispanic, Non-Hispanic Black, Non-Hispanic Other v. Non-Hispanic White), age (30 to 44, 50 to 59, 60 to 69, 70 and above v.18 to 29), education (less than high school, high school, some college or technical school v. degree or above), income level (less than $15,000, $15,000 to less than $25,000, $25,000 to less than $35,000, $35,000 to less than $50,000 v. $50,000 and above) health insurance (not insured v. insured), smoking status (current user, occasional user, former user v. never user), physical activity outside of work (no v. yes), dental visits within the previous year (no v. yes), heavy drinking - men more than 2 drinks per day and women more than 1 drink per day (yes v. no), diabetes (yes v. no), and BMI (25 to less than 30, and over 30 v. less than 25).

ated with stroke independent the established risk factors of gender, age, education, smoking status and body mass index.[13,21-23,29,30] Common risk factors (sex, race/ethnicity, age, education, income, health insurance, smoking status, physical activity, heavy drinking, diabetes and BMI) were included in the multivariable logistic regression analysis as stroke shares etiological factors with periodontal disease and progressive tooth loss.[21] Heitman and Gambourg, in a prospective observational study of 2,932 adult Danes, indicated a hazard ratio of 3.25 for the edentulous participants as compared with participants who had most teeth (highest quintile).[29] With data from the National Health and Nutrition Examination Survey, Wu et al indicated a lower hazard ratio of 1.37 for stroke in people with periodontitis and 11 or more missing teeth compared with people with no periodontal disease, gingivitis or tooth loss.[13] A similar hazard ratio was determined by Choe et al in a prospective study of 867,256 Korean men and women.[30] For men with ≥7 missing teeth, the hazard ratio for stroke was 1.3, and for women the hazard ratio was 1.2.[30]

The proposed mechanisms, by which such an association is biologically plausible, involve direct bacterial challenge (chronic infection), atherogenic bacterial endotoxins and proinflammatory cytokines (which are factors in thromboembolic events).[13,30,31] Tooth loss may suggest a constitutional predisposition to increased inflammatory response after prolonged exposure to inflammatory stressors.[32] There is also a potential altered nutritional status associated with total tooth loss in which citrus fruits (Vitamin C) are often reduced, leading to a proinflammatory state.[32] Another mechanism may be the development of a proinflammatory state in edentulous individuals from chronic Candida albicans infection. More research involving longitudinal surveillance is needed to disentangle the potential mechanisms. Such research will require a standardized definition of periodontal disease, and evidence of tooth loss specific to periodontal disease. Biomarkers for bacterial load would enhance the results.

Some limitations need to be considered with this study. The study participants self-reported number of teeth and misclassification may have occurred, however, the discrepancies would have been random and would have biased estimates to the null. The study participants were not queried about the relative prevalence of superficial caries (not considered to have a role in systemic disease) and periodontal disease.[33] Results of this study should be interpreted with caution. Although results were statistically significant, all 3 adjusted odds ratios for tooth loss were below the standard 2.0 considered epidemiologically to be relevant associations. Additionally, this study was cross-sectional, precluding the use of the more powerful measurement of association, the risk ratio. Of importance, however, is that the odds ratios did increase with additional tooth loss. Therefore, additional studies, such as cohort and interventional trials, should be conducted to further explore these results.

Study strengths include the large, national sam-

ple size with rigorous criteria, validation and reliability in the BRFSS 2010. Additionally, the sample is recent and reflects current population conditions.

Conclusion

Evidence from this cross-sectional study indicates a potential, although weak association that the participants with fewer teeth had increasing adjusted odds ratios for stroke. This study adds to the literature additional support for the association of tooth loss and stroke.

The role of dental hygienists in helping people maintain their teeth is critical. This study indicates the association of having maintained one's teeth and the lowered odds of stroke. Further study is needed to determine if periodontal interventions will decrease the risk of stroke.

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