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Nirmal Mahesh Shah Date: 11/10/2010

Relation between tooth loss and tobacco usage: Findings from the Behavioral Risk Factor Surveillance System.

By

Nirmal Mahesh Shah
Degree to be awarded: Master of Public Health

Department of Epidemiology

Pamela Mink
Faculty Thesis Advisor

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By

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Bachelor of Dental Surgery
Dr. D. Y. Patil Dental College and Hospital, India
2006

Faculty Thesis Advisor: Pamela Mink MPH, PhD

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Nirmal Shah B.D.S., Pamela Mink M.P.H, PhD

ABSTRACT

Background

Smoking cigarettes is associated with increased tooth loss; however research establishing an association between the number of teeth removed and cigarette smoking status as well as smokeless tobacco use status is limited. Moreover, smokeless tobacco may gain social acceptance and become a popular habit in the high school and college campuses. The objective of this study was to evaluate the association between the number of teeth lost and tobacco use (cigarette smoking status and smokeless tobacco use status) in the US adult population.

Methods

We used data from the 2008 Behavioral Risk Factor Surveillance System (BRFSS) to examine the association between self-reported tobacco use (cigarette smoking status and smokeless tobacco use status) and the number of teeth removed due to infection but not due to injury or orthodontic reasons. We estimated the prevalence estimates for each of the selected covariates by the number teeth removed as well as tobacco use (cigarette smoking status and smokeless tobacco use status), and also evaluated the odds ratios with 95% confidence intervals by using multivariate logistic regression model.

Results

In this US adult sample, 31.5% reported removing 1-5 teeth and 11% reported removing 6 or more (but not all) teeth. Respondents who reported to be "current" cigarette smokers had a significantly higher prevalence of 6 or more (but not all) teeth removed when compared to respondents who reported "never" smoking cigarettes (16% vs. 7% for "current" and "never" smokers respectively). In a multivariate logistic regression model adjusting for selected covariates, respondents who reported to be "current" cigarette smokers were 3.5 times as likely to have 6 or more (but not all) teeth removed than respondents who reported to be "never" cigarette smokers. Respondents who are reported being "former" cigarette smokers were 2.2 times as likely to have 6 or more (but not all) teeth removed than respondents who reported "never" smoking cigarettes. The odds of having lost 6 or more (but not all) teeth among "current" smokeless tobacco users were similar to those who reported "never" using smokeless tobacco (OR= 1.1, 95% CI= 1.1 to 1.2).

Conclusion

A strong association was observed between cigarette smoking and number of teeth removed due to infection. Multidisciplinary efforts are needed to raise awareness of the effects of tobacco on tooth loss. Regular dental examinations with periodic dental scaling are important for preventing tooth loss.

Key Words: Smoking; Smokeless tobacco; tooth loss; risk factors.

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Relation between tooth loss and tobacco usage: Findings from the Behavioral Risk Factor Surveillance System.

Nirmal Shah B.D.S., Pamela Mink M.P.H, PhD

Introduction

Teeth play a major role in our everyday living and loss of permanent teeth is associated with serious oral health consequences as well as poor esthetic appearance and low self-esteem. Depending on the severity, tooth loss may lead to naturally drifting teeth in order to occupy the edentulous space created by lost teeth, collapsed bite, and temporomandibular joint problems.

Edentulism or complete tooth loss affects a major proportion of the US senior population. Healthy People 2010[1] has two objectives that address partial or total tooth loss: Objective 21-3 states, "Increase the proportion of adults who have never had a permanent tooth extracted because of dental caries or periodontal disease"; and Objective 21-4 states, "Reduce the proportion of older adults who have all their natural teeth extracted." According to studies conducted in 2007, the prevalence of edentulism among US senior population aged 65 to 74 years has decreased from 29% (1988-1994) to 24% (1999-2004)[2] to 21% (2007)[3]. A study conducted by Centers for Disease Control and Prevention (CDC) and National Institutes of Health (NIH)[4] in 2005 concluded that the prevalence of edentulism increased with age from <1%

among adults aged 20 to 39 years to 25% among those aged ≥ 60 years. Among adults aged ≥ 20 years the prevalence of edentulism in the year 1999-2002 was highest amongst non-Hispanic blacks (9.5%), adults living below 100% Federal Poverty Level (14.6%), current smokers (14.4%) and those with less than a high school education (13.5%).

Dental caries and periodontitis are two major causes of tooth loss. Several studies have highlighted the important role of microorganisms in the progression of dental caries[5, 6]. These microorganisms have been classified into those causing periodontitis and those causing dental caries. General diseases and pathological conditions are also considered to increase the risk for dental disease[7] and vice versa[8].

Smoking may also increase the risk for loss of tooth attachment despite efforts to maintain good oral hygiene. Many US and international studies have reported an association of cigarette smoking with tooth loss[9] and other dental diseases[10, 11]. A 10-year follow-up study conducted by Holm[12] (1994) observed that individuals who smoked more than 15 cigarettes per day were at increased risk of tooth loss and this risk was most pronounced among those who were younger (RR= 4.6) and those who were male (RR= 3.2). Similarly, a study conducted by Elizabeth et al [13] (1997) reported that men who smoked cigarettes had a hazard ratio (HR) of 2.1 for loss of teeth and this hazard declined as the duration of smoking cessation increased from 1year (HR= 2.0) to 15 years (HR=1.0). Yanagisawa et al [14] found that current smokers who had smoked for ≥ 46 years were more likely to have lost more than eight teeth

compared to those who never smoked (OR= 2.0). In addition, the OR of having more than eight missing teeth increased with the number of smoking years prior to cessation among former smokers. A study Dietrich et al [15] (2007) examined the association of cigarette smoking status and smokeless tobacco usage with tooth loss in the prospective Health Professionals Follow-up Study. They reported the following hazard ratios for "ever-use" of chewing tobacco, HR=1.3 (vs. "never-use"); "current" pipe/ cigar smokers, HR=1.2 (vs. "never" or "former"); "current" smokers 5-14 cigarettes/day, HR=2 (vs. "never"); "current" smokers 45+ cigarettes/day, HR=3.2 (vs. "never"). These studies suggest a possible etiological role for tobacco in the causation of dental diseases such as tooth loss.

The objective of the present study was to evaluate the association between the number of teeth removed (except wisdom teeth) due to infection and tobacco use (cigarette smoking status and smokeless tobacco use status) in the US adult population.

Methods

Sampling method

The Behavioral Risk Factor Surveillance System (BRFSS)[16] conducts state-based, random-digit-dialed telephone surveys of the noninstitutionalized U.S. population aged ≥ 18 years to collect data on health conditions and health risk behaviors. The 2008 BRFSS included data from 414,509 respondents, which we used to assess the association between tobacco use statuses with tooth loss. BRFSS estimates were weighted to the respondent's probability of being selected and the age-, sex-, and

race/ethnicity-specific populations from 2008 estimates projected from the 2000 Census for each state, DC, and the U.S territories. These sampling weights were used to calculate all estimates and 95% confidence intervals. Response rates for BRFSS are calculated using Council of American Survey and Research Organizations (CASRO) guidelines. The CASRO Rate is a measure of respondent cooperation and is generally defined as the proportion of all eligible respondents in the sample for whom an interview has been completed. 'The Cooperation Rate is the proportion of all cases interviewed from all the eligible units that were actually contacted. Overall Response Rate below 30% should cause review of data collector practices that could impact it, especially sample management and interviewer recruitment, retention, supervision and monitoring. A Cooperation Rate below 65% indicates some problem with interviewing techniques.[17]' Median survey Response Rates were 53.3% and median Cooperation Rates were 75.0% for the BRFSS 2008 survey. All BRFSS questionnaires, data and reports are available at www.cdc.gov/brfss.

Variables

The outcome and other teeth-related variables were: (1) Dental health variables: (a) Number of teeth removed, (b) Professional teeth cleaning, (c) Dental visits;

The principal exposure variables were: (2) Tobacco use variables: (a) Cigarette smoking status, (b) Smokeless tobacco user; and

Additional variables were: (3) Self- reported socio-demographic, co-morbidities and general health status variables.

(1) Dental health variables:

(a) Number of teeth removed

Tooth loss was defined using one question: "How many of your permanent teeth have been removed because of tooth decay or gum disease?" Teeth lost because of infection were included in this definition, but losses due to injury or orthodontics were not. Responses to this question were entered in four predefined tooth loss categorizes: none, 1 to 5 teeth lost, 6 or more (but not all) teeth lost, and all teeth lost.

(b) Professional teeth cleaning

Professional teeth cleaning was queried by the following questions: "How long has it been since you had your teeth cleaned by a dentist or dental hygienist?" The information collected on recent teeth cleaning was entered as a nominal variable with following categories: teeth cleaned less than 12 months ago, teeth cleaned 1 year to less than 2 years ago, teeth cleaned 2 years to less than 5 years ago, teeth cleaned 5 or more years ago, never teeth cleaned. Participants who reported "all teeth lost" were not asked the question. Because we wanted to consider responses to this item as a potential confounding factor in multivariate analyses; we excluded from further analyses the 5% of total respondents who reported having lost all their teeth. Unfortunately, information on age at which all teeth were lost was not collected.

(c) Dental visit

Respondents were asked, "How long has it been since you last visited a dentist or a dental clinic for any reason?" Responses to this question were entered in four

predefined categorizes: less than 12 months ago, 1 to less than 2years ago, 2 to less than 5 years ago, 5 or more years ago, and never visit a dental clinic.

(2) Tobacco use variables:

(a) Cigarette smoking status

Respondents were asked the following questions about smoking cigarettes: "Have you smoked at least 100 cigarettes in your entire life?" and "Do you now smoke cigarettes every day, some days, or not at all?" A never smoker was defined as a respondent who had never smoked 100 cigarettes. A current smoker was defined as a respondent who had smoked at least 100 cigarettes and was currently smoking. A former smoker was defined as someone who had smoked 100 cigarettes but was not currently smoking cigarettes. Data on duration and intensity of smoking were not collected in the 2008 BRFSS.

(b) Smokeless tobacco use

In BRFSS the "Other tobacco product" was an optional module for the year 2008 adopted by 11 states (Delaware, Florida, Indiana, Louisiana, Nebraska, North Carolina, Tennessee, Texas, West Virginia, Wisconsin and Wyoming.) Respondents were asked "Have you ever used or tried any smokeless tobacco products such as chewing tobacco, snuff, or snus?" and "Do you currently use chewing tobacco, snuff, or snus every day, some days, or not at all?" Responses to the former question were "yes" or "no" while those for the latter were "every day," "some days" or "not at all."

Use of smokeless tobacco was categorized to "never" "former" or "current" as for cigarette smoking.

3) Self- reported socio-demographic, co-morbidities and general health status variables:

Self-reported weight and height were used to calculate Body Mass Index (BMI). Respondents were asked "About how much do you weigh without shoes?" and "About how tall are you without shoes?" BMI was calculated (kg/m^2). Respondents were classified as underweight (BMI < 18.5), normal weight (BMI 18.5 to < 25), overweight (BMI 25 to < 30), or obese (BMI ≥ 30). Education level was assessed by asking the question, "What is the highest grade or year of school you completed?" Three categories were created as follows: "high school graduate or less," "some college or technical school," and "college graduate." Federal Information Processing Standards Publication – Counties and County Equivalents of the United States and the District of Columbia (FIPS) was used to assess each respondent's Metropolitan Status Code. 'Metropolitan Statistical Areas (MSA) have at least one urbanized area of 50,000 or more population plus adjacent territory that has a high degree of social and economic integration with the core as measured by community ties[18]'. General health status was assessed by asking the following question with five optional responses, "Would you say that in general your health is – excellent, very good, good, fair or poor." Diabetes was assessed by asking the question, "Have you ever been told by a doctor that you have diabetes?" with optional categorized responses, "Yes", "Yes, but female told only during pregnancy", "No", "No, pre-diabetes or borderline diabetes."

Age was coded in years by asking the question, “What is your age?” Computed five-level race/ethnicity variable was used in this analysis having categories, “white” , “black” , “hispanic”, “multiracial” and “other.” Annual household income information was collected by the following question with eight-level categories, “Is your annual household income from all sources – less than $10000, $10,000 to less than $15000, $15000 to less than $20000, $20000 to less than $25000, $25000 to less than $35000, $35000 to less than $50000, $50000 to less than $75000 and $75000 or more.” Information on gender was collected by asking the respondents, “Indicate your sex?” with optional responses, “male” or “female”.

Statistical analyses

We began our process of evaluating potential confounding by using causal diagrams. Our exposure of primary interest was tobacco use and the outcome was number of teeth lost. We reviewed the literature to identify factors that were potentially associated with both the exposure of primary interest and the outcome. We then reviewed the available variables in BRFSS to identify and include them in our evaluation of confounding. The distribution of each of these selected variables was then assessed across each teeth lost category (no teeth removed, 1-5 teeth removed, 6 or more but not all teeth removed) and across cigarette smoking status and smokeless tobacco use status (never, former, current). This process guided our choice of which variables would be evaluated further by examining bivariate associations with the exposure variables of primary interest (cigarette smoking status and smokeless tobacco use status) and the outcome variable (number of teeth removed).

Multivariate regression analyses were conducted using unconditional logistic regression. The unadjusted model contained the independent variable as cigarette smoking status (MODEL 1) or smokeless tobacco use status (MODEL 2) with number of teeth removed as the dependent variable for both models; the values entered for these independent variables were considered to have a specific order. Ordinal logistic regression could not be used as the score test was highly significant, indicating that the variables should be treated as nominal variables i.e., the categories of the independent variable cannot be ordered in any meaningful way[19]. Therefore, multinominal logistic regression modeling was employed to calculate odds ratio (OR) estimates and 95% confidence intervals (CI). Number of teeth removed was categorized into three categories (no teeth removed, 1-5 teeth removed and 6 and more but not all teeth removed); respondents with no teeth removed were considered as the "non-cases". Dummy variables were also created for each level of the categorical exposure variables to be modeled against the outcome variable. Thereafter, the initial model generated an unadjusted OR for the association between the outcome variable (teeth removed) with the independent variable (cigarette smoking status) (MODEL 1). The same modeling technique was used for estimating the association between the outcome variable i.e., number of teeth removed with the independent variable i.e., smokeless tobacco user status (MODEL 2). In each of these models "never" smokers or "never" smokeless tobacco users was modeled as the reference category, respectively.

a> Cigarette Smoking

We built the multivariate logistic regression models by adding and removing one variable at a time, and evaluated the change in the point estimates for the association between cigarette smoking status with the number of teeth removed. Then the covariates (age, gender, race, education, income, teeth cleaned, dental visit, and health) that produced an OR estimate meaningfully different from the unadjusted OR were included in the subsequent multivariate model. We then individually adjusted for each of the previously eliminated covariates (BMI, living together, diabetes, insurance and MSA) to evaluate whether their inclusion in the "new" model produced a meaningful difference in the OR estimate. After this, BMI was retained in the "final" model containing the other covariates (age, gender, race, education, income, teeth cleaned, dental visit, and health).

b> Smokeless Tobacco

A procedure similar to Model 1 was used to analyze the association between smokeless tobacco use and number of teeth removed. The final model here contained the following covariates: age, gender, race, education, income, teeth cleaned, dental visit, health and living together.

There was no hypothesized interaction between tobacco exposure and the covariates based on the available literature search and evaluation of the causal diagrams. Hence, the final model was not stratified by any covariates. For all analyses, p value < 0.05

were considered statistically significant. All analyses were conducted using Statistical Analysis Software (SAS) version 9.2 (SAS Institute, Cary, NC).

Results

The 2008 BRFSS included data from 414,509 respondents which were 48.6% males and 51.4% females; 78.6% whites and 4.3% blacks; and 17.2% of the age group ≥ 65 yrs. Table 1 presents the distribution of number of teeth lost by selected characteristics. Of the total number of respondents, 57.6 % reported having all their teeth, 31.5% reported 1 to 5 missing teeth and 11 % reported 6 and more but not all teeth missing. In comparison with those who had reported losing no teeth, respondents who had reported more teeth removed tended to be older. About 73% of the respondents age 18 to 44 years reported no missing teeth, whereas 28.6% of respondents age 65 and older reported retaining all their teeth. Attained education was inversely associated with number of teeth lost; 5.4% of college graduates reported 6-27 teeth missing as compared to 16.2% of those with a high school degree or less. Income was also inversely associated with number of teeth lost. Sixty percent of whites reported no missing teeth whereas 44.3% of blacks reported retaining all their teeth. Respondents reporting recent visits to a dental clinic and/ or professional teeth cleaning also reported fewer lost teeth in contrast to those having visited their dentist and/ or professional teeth cleaning more than 5 years ago or never at all. Furthermore, 7% of the respondents who reported being “never” cigarette smokers reported losing 6 to 27 teeth but about 16% of the respondents who reported being “former” or “never” cigarette smoker reported having lost 6 to 27 teeth.

Table 2 presents the distribution of cigarette smoking status by selected characteristics. Of the total number of respondents, 18.4% reported being "current" cigarette smokers, 24.4% reported being "former" smokers and 57.2% reported being "never" smokers. About 21% of the respondents age 18 to 44 years reported currently smoking cigarettes, whereas 8% of the respondents age ≥ 65 years reported currently smoking cigarettes. Attained education was associated inversely with current smoking status; 25% of the respondents with a high school degrees or less reported currently smoking cigarettes as compared to 9% of those with college degrees. Although fewer whites reported being "current" smokers than blacks, the difference was not materially different (18.8% vs. 20.6% for whites and blacks respectively.) Nearly 60% of respondents reporting recent visit to a dental clinic and/ or professional teeth cleaning reported "never" smoking cigarettes as compared to 44% of those who reported having visited a dental clinic and or professional teeth greater than 5 years ago or not at all.

Tables 3 and 4 present the number of teeth lost and smokeless tobacco use status by selected characteristics respectively. The BRFSS "other tobacco products" module was made optional in 2008 and thereby used only by 11 states (Delaware, Florida, Indiana, Louisiana, Nebraska, North Carolina, Tennessee, Texas, West Virginia, Wisconsin and Wyoming). Thus tables (Table 3 and 4) are sub-sets of the entire dataset. Nearly 6% of the respondents reporting as "current" users of smokeless tobacco reported 6 to 27 missing teeth and about 10% of the respondents reporting

"never" using smokeless tobacco also reported 6 to 27 teeth missing teeth. Also, 8% of the whites reported as currently using smokeless tobacco in contrast to 1% of the blacks.

Table 5 shows results of multivariate regression analyses for the association between number of teeth removed and cigarette smoking status among US adults age ≥ 18yrs using BRFSS 2008. Adjusting for age resulted in attenuation of the ORs for former smokers and an increase in the ORs for current smokers for both categories of tooth loss. Addition of socio-demographic characteristics (age, race, gender, education and income), dental care variables (professional teeth cleaning, dental visit) and the general health status variable to the model had a modest effect on the associations with former smoking, but the associations with current smoking were similar to those in the unadjusted model, particularly for the 1-5 teeth lost category. Further addition of BMI (Model 4) resulted in a small increase in the ORs with the exception of current smokers in the 6-27 teeth removed category. Respondents who reported to be "current" cigarette smokers were 3.5 times as likely to have lost 6 to 27 teeth as those who reported "never" smoked cigarettes. In addition, respondents who reported being "former" smokers were 2.2 times as likely to have lost 6 to 27 teeth as those who reported "never" smoked cigarettes. Respondents who reported to be "current" cigarette smokers were 1.8 times as likely to have lost 1 to 5 teeth as those who reported "never" smoking cigarettes.

Table 6 shows results of analysis for the association between number of teeth removed and smokeless tobacco user status among US adults age ≥ 18yrs using BRFSS 2008. Adjusting for age produced a modest increase in the ORs for the former smokers except for the current smokers in both categories of teeth removed. Addition of socio-demographic characteristics (age, race, gender, education and income), dental care variables (professional teeth cleaning) and health status variable to the model resulted in an increase in the ORs for the current smokeless tobacco users, particularly in the 6-27 teeth removed category. The associations with "former" smokeless tobacco use were very similar to those in the unadjusted models. Further addition of dental visit and living together variables (Model 4) had a modest effect on associations with current smokeless tobacco use. The odds of having lost 6 to 27 teeth among respondents who reported to be "current" smokeless tobacco users were about the same (OR=1.1) as those who reported "never" using smokeless tobacco. In addition, respondents who reported being "current" smokeless tobacco users were 1.2 times as likely to have lost 1-5 teeth as those who have reported "never" using smokeless tobacco.

Discussion

These findings suggest that current and former cigarette smokers are more likely to have lost teeth than nonsmokers, after controlling for the potential confounding factors like age, race, gender, education, income, professional teeth cleaning, dental visit, health and BMI. Also, as expected, age is a strong predictor for loss of permanent teeth. Smokeless tobacco users, both current and former, were not more likely to have

lost teeth than non-smokeless tobacco users. The effect of tobacco was restricted to loss of teeth itself and therefore overall effects on health were not analyzed.

It is important to consider these results in light of several limitations. The socio-demographic distribution in Table 7 indicates that blacks among the 2008 BRFSS data are underrepresentated when compared to 2008 National Health Interview Survey (NHIS) data (4.3% vs. 12.0% for BRFSS and NHIS respectively) and also to 2009 US Census Bureau (13%)[20]. As the BRFSS sample was drawn from a noninstitutionalized population, it excludes adults not residing in households (e.g., those in nursing homes or long-term care facilities). It does not sample persons in households without any telephone service (1.9%) (e.g., those with lower incomes) or with only wireless telephones (20.2%); and adults with only wireless service are more likely (26.5%) than the rest of the U.S. population to be current smokers. All of these potentially affect generalizability and external validity of the association between tobacco users status (cigarette smokers and smokeless tobacco user) with number of teeth removed.

In addition, the accuracy of survey participants self-report of their dental visits was not validated against dental records. Therefore, the responses might be subject to misclassification and/or the tendency to give socially desirable response during interviews. The estimates for cigarette smoking and smokeless tobacco are also based on self-report and are not validated by biochemical tests or other means. However, self-reported data on current smoking status have high validity[21, 22]. Furthermore, this study is an observational study and a potential unobserved confounder related to both

the number of teeth removed and tobacco usage could affect the result of this study. The duration, intensity of cigarette smoking and the year since quitting smoking and all teeth lost was also not measured in this study. Even though we did not have data on attachment loss, bleeding gums and alveolar bone loss; these variables are likely on the causal pathway and therefore should not be included in the multivariate model as potential confounders.

Also, the median response rate in all states and DC was 53.3% (range: 35.8% - 65.9%). Low response rates might indicate a potential for selection bias such that smoking prevalence might be underestimated if smokers are less likely to respond to a survey or respondents who have retained all their teeth with good self-reported health condition are more likely to participate in the survey. Overall low response rates would affect the generalizability of the study; extent of bias in the observed ORs would depend on the distribution of exposure and outcome among participants vs. non-participants (i.e., the selection probabilities).

The strengths of the BRFSS include that it is relatively inexpensive and accessible resource to evaluate public health data. As it is a population-based survey having a large sample size it allows the data to be generalized to US adult population, albeit with the same caveats as discussed previously. The BRFSS is a state-based, random-digit-dialed telephone surveys conducted annually for many years. Thus each state can compare their data with other as well as analyze the data for trends over time.

In summary, the association between cigarette smoking and tooth removed due to infection in this study was strong. Therefore, preventing smoking or facilitating smoking cessation should reduce loss of permanent teeth, prevent costly periodontal therapy and improve oral health. Promoting the side-effects of tobacco can help battle the problem at both primary and secondary levels of prevention.

Finally, the mechanism of tooth loss is still an ever-expanding area with tobacco usage playing a significant role. The difference in the demonstrated effect of smoking cigarettes and usage of smokeless tobacco on tooth loss is not fully understood. Further clinical studies are needed to fully elucidate the difference in the mechanism of tooth loss pertaining to cigarette smoking and use of smokeless tobacco.

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Tables

Table 1: Number of teeth removed by selected demographic, behavioral and health characteristics, US adults age ≥18yrs, BRFSS† 2008.

Variables		Teeth removed*			
		No teeth removed	1-5 teeth removed	6 and more not all teeth removed	Chisq P value
		%	%	%	
Total		57.6	31.5	11	
Age	18 to 44	72.7	24.2	3.1	<0.05
	45 to 64	46.4	38.7	14.9	
	65 and above	28.6	40.8	30.6	
Gender	Male	58.0	31.7	10.3	<0.05
	Females	57.2	31.3	11.6	
Race	Whites	60.0	29.0	11.0	<0.05
	Blacks	44.3	39.4	16.3	
	Other	58.1	32.2	9.7	<0.05
	Multiracial	57.1	29.6	13.3	
	Hispanic	55.8	36.8	7.4	
Education	High school grad or less	47.0	36.8	16.2	<0.05
	College/Technical	57.8	31.6	10.7	
	College grad	69.2	25.5	5.4	
Income	Less than 25,000	43.8	36.9	19.4	<0.05
	25,000 to <50,000	51.1	35.6	13.3	
	50,000 to <75,000	60.6	31.4	8.1	
	75,000 and more	70.6	25.0	4.4	
Living together	Living together	57.4	32.6	10.0	<0.05
	Not Living together	57.9	29.5	12.6	
Insurance	Yes, Insurance	58.0	30.9	11.1	<0.05
	No, Insurance	54.9	34.7	10.4	
BMI	Normal	64.0	27.4	8.5	<0.05
	Overweight	56.3	32.5	11.2	
	Obese	50.4	35.5	14.1	
Health	Excellent/Very good	66.9	27.1	6.0	<0.05
	Good	51.7	35.7	12.6	
	Fair/Poor	35.4	39.0	25.6	
MSA¶	Yes, MSA	59.1	30.8	10.1	<0.05
	No, MSA	51.9	33.5	14.6	
Teeth clean	Less than 1 year	60.3	31.1	8.6	<0.05
	1-2 year	54.9	33.1	12.1	
	2-5 year	51.2	34.2	14.7	
	5 and more/never	47.2	31.2	21.6	
Dental visit	Less than 1 year	59.1	31.5	9.4	<0.05
	1-2 year	53.7	33.6	12.7	
	2-5 year	51.5	33.7	14.8	

	5 and more/never	**56.5**	**26.6**	**16.9**	
Cigarette Smoking	**Current**	**47.4**	**36.3**	**16.3**	**<0.05**
	Former	**47.4**	**35.8**	**16.8**	
	Never	**64.8**	**28.3**	**6.9**	
Diabetes	**Yes, Diabetes**	**55.3**	**33.4**	**11.3**	**<0.05**
	No, Diabetes	**64.5**	**27.5**	**8.1**	

† Behavioral Risk Factor Surveillance System.
*** Respondents with all teeth removed were excluded from the analysis.**
¶ Metropolitan Statuscode.

Table 2: Cigarette smoking status by selected demographic, behavioral and health characteristics, US adults age ≥18yrs, BRFSS† 2008.

Variables		Smokestatus*			
		Current	Former	Never	Chisq P value
		%	%	%	
Total		18.4	24.4	57.2	
Age	18 to 44	21.3	15.0	63.7	<0.05
	45 to 64	19.2	29.3	51.6	
	65 and above	8.3	42.2	49.5	
Gender	Male	20.1	27.8	51.5	<0.05
	Females	16.2	21.1	62.7	
Race	Whites	18.8	27.5	53.7	<0.05
	Blacks	20.6	17.0	62.4	
	Other	15.9	18.8	65.3	
	Multiracial	27.5	22.2	50.3	<0.05
	Hispanic	15.6	17.2	67.3	
Education	High school grad/less	25.3	23.8	50.9	
	College/Technical	20.0	25.6	54.4	<0.05
	College grad	8.9	24.1	67.0	
Income	Less than 25,000	26.4	21.6	52.0	
	25,000 to <50,000	21.5	25.6	52.9	<0.05
	50,000 to <75,000	16.4	26.9	56.7	
	75,000 and more	11.3	25.5	63.3	
Living together	Living together	15.3	27.1	57.6	<0.05
	Not Living together	23.9	19.5	56.6	
Insurance	Yes, Insurance	16.0	26.0	58.0	<0.05
	No, Insurance	31.8	15.7	52.5	
BMI	Normal	20.3	20.3	59.4	
	Overweight	17.7	26.7	55.6	<0.05
	Obese	17.5	27.5	55.0	
Health	Excellent/Very good	14.4	23.0	62.6	
	Good	21.6	24.2	54.2	<0.05
	Fair/Poor	25.3	29.1	45.6	
MSA¶	Yes, MSA	17.7	24.2	58.1	<0.05
	No, MSA	22.2	25.6	52.2	
Teeth clean	Less than 1 year	13.5	24.5	62.0	
	1-2 year	21.9	21.9	56.2	<0.05
	2-5 year	27.3	21.1	51.6	
	5 and more/never	33.0	23.1	43.9	
Dental visit	Less than 1 year	14.6	24.9	60.5	
	1-2 year	22.9	21.8	55.3	<0.05
	2-5 year	27.6	22.8	49.7	
	5 and more/never	30.2	25.6	44.3	
Diabetes	Yes, Diabetes	17.6	26.4	56.1	<0.05

	No, Diabetes	**22.8**	**19.1**	**58.1**	

† Behavioral Risk Factor Surveillance System.
*** Smokestatus was categorized based on self-reported cigarette smoking exposure.**
¶ Metropolitan Statuscode.

Table 3: Number of teeth removed by selected demographic, behavioral and health characteristics, US adults age ≥18yrs, among 11 states answering tobacco optional module[†], ≥ age 18, BRFSS[±] 2008.

Variables & Subcategories		Teeth removed[‡]			
		No teeth removed	1-5 teeth removed	6 and more not all teeth removed	Chisq P value
		%	%	%	
Age	18 to 44	75.5	21.6	3.0	<0.05
	45 to 64	49.6	37.7	12.7	
	65 and above	28.2	45.1	26.7	
Gender	Male	60.4	29.8	9.8	<0.05
	Females	58.6	31.6	9.8	
Race	Whites	59.8	30.4	9.7	<0.05
	Blacks	79.4	16.6	4.0	
	Other	46.8	36.8	16.4	<0.05
	Multiracial	61.6	25.6	12.7	
	Hispanic	56.9	36.3	6.8	
Education	High school grad or less	50.4	35.4	14.1	<0.05
	College/Technical	58.8	31.5	9.7	
	College grad	70.8	24.5	4.8	
Income	Less than 25,000	46.4	35.6	18.0	<0.05
	25,000 to <50,000	53.9	32.5	13.6	
	50,000 to <75,000	59.9	32.5	7.6	
	75,000 and more	69.0	26.3	4.7	
Living together	Living together	58.9	32.0	9.1	<0.05
	Not Living together	60.8	27.9	11.3	
Insurance	Yes, Insurance	60.5	29.9	9.7	<0.05
	No, Insurance	53.0	36.2	10.8	
BMI	Normal	65.0	26.9	8.1	<0.05
	Overweight	59.7	30.5	9.8	
	Obese	50.7	36.6	12.7	
Health	Excellent/Very good	67.4	26.6	6.1	<0.05
	Good	52.2	35.8	12.0	
	Fair/Poor	38.3	38.8	22.9	
MSA[¶]	Yes, MSA	60.2	29.9	9.9	<0.05
	No, MSA	59.2	31.0	9.8	
Teeth clean	Less than 1 year	62.0	30.1	8.0	<0.05
	1-2 year	56.7	33.8	9.5	
	2-5 year	57.2	31.4	11.4	
	5 and more/never	50.7	31.8	17.5	
Dental visit	Less than 1 year	60.7	30.3	9.1	<0.05
	1-2 year	54.3	36.1	9.7	
	2-5 year	55.2	36.3	12.5	
	5 and more/never	59.8	27.0	13.2	

Cigarette smokers*	Current	44.8	35.9	19.3	<0.05
	Former	48.6	36.4	15.0	
	Never	68.8	26.6	4.6	
Smokeless** tobacco	Current	64.3	29.9	5.8	<0.05
	Former	59.2	29.9	10.9	
	Never	61.6	28.8	9.6	
Diabetes	Yes, Diabetes	55.3	33.4	11.3	<0.05
	No, Diabetes	64.5	27.5	8.1	

† Analysis of teeth removed was restricted to states answering the other tobacco products optional module.

± Behavioral Risk Factor Surveillance System.

‡ Respondents with all teeth removed were excluded from the analysis.

¶ Metropolitan Statuscode.

*** Cigarette smoking was categorized based on self-reported cigarette smoking exposure.**

**** Other tobacco products questionnaire was an option module and used by 11 states.**

Table 4: Smokeless tobacco use status by selected demographic, behavioral and health characteristics, US adults age ≥18yrs, among 11 states answering tobacco optional module, ≥ age 18, BRFSS‡ 2008.

Variables		Smokeless Tobacco*			
		Current	Former	Never	Chisq P value
		%	%	%	
Age	18 to 44	10.9	28.1	61.0	<0.05
	45 to 64	6.6	23.4	70.0	
	65 and above	2.2	15.3	82.6	
Gender	Male	14.9	38.9	46.2	<0.05
	Females	0.8	9.5	89.7	
Race	Whites	8.2	24.8	67.0	<0.05
	Blacks	1.1	14.2	84.7	
	Other	6.6	26.4	67.0	<0.05
	Multiracial	12.1	24.6	63.3	
	Hispanic	4.1	15.8	80.1	
Education	High school grad or less	9.2	24.5	66.4	<0.05
	College/Technical	8.5	23.4	68.1	
	College grad	5.6	25.1	69.3	
Income	Less than 25,000	7.1	21.0	71.9	<0.05
	25,000 to <50,000	7.1	24.6	68.3	
	50,000 to <75,000	7.2	24.1	68.7	
	75,000 and more	9.8	28.2	62.0	
Living together	Living together	7.3	25.2	67.6	<0.05
	Not Living together	9.4	22.4	68.2	
Insurance	Yes, Insurance	7.8	24.5	67.7	<0.05
	No, Insurance	8.4	23.2	68.3	
BMI	Normal	7.0	20.1	72.9	<0.05
	Overweight	9.7	27.8	62.4	
	Obese	7.5	27.3	65.2	
Health	Excellent/Very good	8.2	24.7	67.0	<0.05
	Good	7.6	24.9	67.5	
	Fair/Poor	7.0	21.0	72.1	
MSA¶	Yes, MSA	5.2	22.5	72.4	<0.05
	No, MSA	8.9	25.0	66.1	
Teeth clean	Less than 1 year	6.2	23.0	70.8	<0.05
	1-2 year	11.4	26.1	62.5	
	2-5 year	11.2	25.1	63.6	
	5 and more/never	12.6	30.4	57.0	
Dental visit	Less than 1 year	6.2	23.4	70.4	<0.05
	1-2 year	11.4	26.7	61.9	
	2-5 year	10.3	26.4	63.3	
	5 and more/never	12.3	25.5	62.2	

Cigarette smokers	**Current**	**9.2**	**33.6**	**57.2**	**<0.05**
	Former	**9.1**	**31.2**	**59.7**	
	Never	**6.9**	**17.9**	**75.2**	
Teeth removed†	**None**	**8.7**	**25.5**	**65.8**	**<0.05**
	1-5teeth	**8.0**	**23.2**	**68.8**	
	6+more, but not all	**6.1**	**24.2**	**69.8**	
Diabetes	**Yes, Diabetes**	**7.0**	**24.4**	**68.7**	**<0.05**
	No, Diabetes	**9.1**	**23.7**	**67.3**	

‡ Behavioral Risk Factor Surveillance System.
*** Other Tobacco products questionnaire was an optional module and used by 11 states.**
¶ Metropolitan Statuscode.
† Respondees with all teeth removed were excluded from the analysis.

Table 5: Odds ratio and confidence intervals using polytomous modeling† for BRFSS* 2008, cigarette smoking status was modeled as the main exposure variable and number of teeth removed as the outcome variable.

Number of teeth removed	Smoking Status	Model 1	Model 2	Model 3	Model 4**
1-5 teeth removed	Never	1.0	1.0	1.0	1.0
	Former	1.73 (1.72-1.73)	1.39 (1.38-1.39)	1.44 (1.43-1.44)	1.43 (1.42-1.43)
	Current	1.75 (1.75-1.76)	2.08 (2.07-2.08)	1.75 (1.74-1.75)	1.78 (1.77-1.78)
6 - 27 teeth removed	Never	1.0	1.0	1.0	1.0
	Former	3.31 (3.32-3.32)	2.13 (2.13-2.14)	2.22 (2.22-2.23)	2.19 (2.19-2.20)
	Current	3.22 (3.21-3.22)	5.29 (5.29-5.30)	3.40 (3.39-3.41)	3.53 (3.53-3.54)

† Selected modeling outputs are represented in the table
* Behavioral Risk Factor Surveillance System
** Best Model

Variables adjusted in the models:

Model1 – Unadjusted

Model 2 – Age

Model 3 - Race (Whites, Blacks, Other, Multiracial, Race), Age (18 to 44, 45 to 64, 65 and above), Gender (Male, Female), Education (High School Grad or less, Some college/Technical school, College grad), Income (Less than 25,000, 25,000 to <50,000, 50,000 to <75,000, 75,000 and more), Teeth cleaned (Less than 1 year, 1-2 year, 2-5 year, 5 and more years/no teeth cleaning), Dental Visit (Less than 1 year, 1-2 year, 2-5 year, 5 and more years/no dental visit), Health (Excellent/Very good, Good, Fair/Poor),

Model 4 - Race (Whites, Blacks, Other, Multiracial, Race), Age (18 to 44, 45 to 64, 65 and above), Gender (Male, Female), Education (High School Grad or less, Some college/Technical school, College grad), Income (Less than 25,000, 25,000 to <50,000, 50,000 to <75,000, 75,000 and more), Teeth cleaned (Less than 1 year, 1-2 year, 2-5 year, 5 and more years/no teeth cleaning), Dental Visit (Less than 1 year, 1-2 year, 2-5 year, 5 and more years/no dental visit), Health (Excellent/Very good, Good, Fair/Poor), BMI (Normal, Overweight, Obese).

Table 6: Odds ratio and confidence intervals using polytomous modeling† for BRFSS* 2008, smokeless tobacco user status was modeled as the main exposure variable and number of teeth removed as the outcome variable.

Number of teeth removed	Smokeless Tobacco user	Model 1	Model 2	Model 3	Model 4**
1-5 teeth removed	Never	1.0	1.0	1.0	1.0
	Former	0.93 (0.92-0.94)	1.02 (1.01-1.02)	1.05 (1.04-1.05)	1.04 (1.03-1.05)
	Current	0.88 (0.86-0.91)	1.2 (1.17-1.23)	1.21 (1.17-1.25)	1.24 (1.21-1.28)
6 - 27 teeth removed	Never	1.0	1.0	1.0	1.0
	Former	0.95 (0.93-0.96)	1.13 (1.12-1.14)	1.13 (1.11-1.15)	1.12 (1.10-1.14)
	Current	0.66 (0.63-0.69)	1.26 (1.20-1.32)	1.09 (1.03-1.15)	1.14 (1.08-1.21)

† Selected modeling outputs are represented in the table
* Behavioral Risk Factor Surveillance System
**Best Model

Variables adjusted in the models:

Model 1 – Unadjusted

Model 2 – Age

Model 3 - Race (Whites, Blacks, Other, Multiracial, Race), Age (18 to 44, 45 to 64, 65 and above), Gender (Male, Female), Education (High School Grad or less, Some college/Technical school, College grad), Income (Less than 25,000, 25,000 to <50,000, 50,000 to <75,000, 75,000 and more), Teeth cleaned (Less than 1 year, 1-2 year, 2-5 year, 5 and more years/no teeth cleaning), Health (Excellent/Very good, Good, Fair/Poor).

Model 4 - Race (Whites, Blacks, Other, Multiracial, Race), Age (18 to 44, 45 to 64, 65 and above), Gender (Male, Female), Education (High School Grad or less, Some college/Technical school, College grad), Income (Less than 25,000, 25,000 to <50,000, 50,000 to <75,000, 75,000 and more), Teeth cleaned (Less than 1 year, 1-2 year, 2-5 year, 5 and more years/no teeth cleaning), Dental Visit (Less than 1 year, 1-2 year, 2-5 year, 5 and more years/no dental visit), Health (Excellent/Very good, Good, Fair/Poor), Living together (Living together, Not living together).

Table 7: Sample representation of BRFSS* 2008 data and NHIS† 2008 by socio-demographic and cigarette smoking status.

Variable	Subcategories	BRFSS 2008	Variable	Subcategories	NHIS 2008
Gender	Male	48.6	Gender	Male	48.3
	Female	51.4		Female	51.7
Race	White	78.6	Race	Whites	81.1
	Blacks	4.3		Blacks	11.9
	Hispanic	5.2		Other	5.8
	Other	4.0		Multiple race	1.3
	Multiple race	1.3			
Age	18-24 years	12.5	Age	18-24 years	12.9
	25-34 years	17.8		25-34 years	18.1
	35-44 years	18.3		35-44 years	18.7
	45-54 years	19.2		45-54 years	19.7
	55-64 years	14.9		55-64 years	15.1
	65+ years	17.2		65+ years	15.5
Education	Less than H.S.	9.2	Education	Less than H.S.	10.2
	H.S. or G.E.D	29.7		H.S. or G.E.D	23.8
	Some post-H.S.	26.7		Some post-H.S.	31.6
	College+	31.6		College+	34.4
Income	Less than $15,000	8.2	Family Income	Less than $35,000	34.5
	$15,000-24,999	15.1		$35,000 - 74,999	28.6
	$25,000-34,999	11.5		$75,000 - 99,999	9.2
	$35,000-49,999	15.5		$100,000 +	14.9
	$50,000+	48.5		Undefined	12.8
Cigarette smoking status	Smoke everyday	13.4	Cigarette smoking status	Smoke everyday	16.5
	Smoke some days	4.9		Smoke some days	4.2
	Former smoker	25.1		Former smoker	21.6
	Never smoked	55.5		Never smoked	57.8

* Behavioral Risk Factor Surveillance System.
† National Health Interview Survey

Bibliography

BRFSS - Behavioral Risk Factor Surveillance System.

CASRO - Council of American Survey and Research Organizations.

CDC - Centers of Disease Control and Prevention.

FIPS - Federal Information Processing Standards.

HR - Hazard Ratio.

NIH - National Institute of Health Survey.

OR - Odds Ratio.

RR - Relative Risk.