Weintraub Jane (Orcid ID: 0000-0001-7178-2028)
Phillips Ceib (Orcid ID: 0000-0001-6845-7320)

Factors Associated with Becoming Edentulous in the U.S. Health and Retirement Study

Running title: Factors Associated with Becoming Edentulous

Jane A. Weintraub, DDS, MPH[a,b], Brian Orleans, B[b], Margherita Fontana, DDS, PhD[c], Ceib Phillips, PhD, MPH[a], Judith A. Jones, DDS, MPH, DScD[d]

[a] Adams School of Dentistry, University of North Carolina at Chapel Hill

[b] Gillings School of Global Public Health, University of North Carolina at Chapel Hill

[c] School of Dentistry, The University of Michigan

[d] School of Dentistry, University of Detroit Mercy

A brief version of this paper was presented at the International Association for Dental Research, London, England, July, 2018.

Address correspondence to:

Jane A. Weintraub, DDS, MPH, University of North Carolina at Chapel Hill Adams School of Dentistry, 4508 Koury Oral Health Sciences Building, Chapel Hill, NC 27599-7450.

E-mail: Jane_Weintraub@unc.edu Telephone: 919-537-3240

Word counts for Abstract (260), Main text (2684) Number of tables: 2, figures: 2, supplementary tables (2)

Funding sources: Not applicable other than salaries from universities listed. Data are from a public use database.

ABSTRACT

BACKGROUND/OBJECTIVE: To determine factors associated with older adults becoming edentulous (complete tooth loss).

DESIGN: Longitudinal study over six-year period.

SETTING: United States, 2006, 2012.

PARTICIPANTS: Nationally representative United States sample of adults age 50 and older (n=9,982) participating in the Health and Retirement Study (HRS) in 2006 and 2012. At the outset they were dentate and not institutionalized.

INTERVENTION: None

MEASUREMENTS: Self-report of being dentate or edentulous, demographic variables, dental utilization and other health behaviors, self-rated general health, and incidence between 2006-2012 of comorbid medical conditions, functional limitations and disabilities.

RESULTS: From 2006-2012, 563 (5%) individuals became edentulous and 9,419 remained dentate (95%). Adults who became edentulous by 2012 were more likely than those who remained dentate to be Black/African-American compared to White, less educated, current smokers, persons with diabetes, and reported poorer self-rated general health, more functional limitations and disabilities and fewer dental visits (all $p < 0.0001$) among other factors. Of those with regular dental visits (at least once every two years during the 6-year period), 2.3% became edentulous compared to 9.9% among those without regular dental visits. After adjusting for age and other potential confounders, there was a strong association with poor dental attendance and

smoking. Non-regular dental attenders were more likely than regular attenders to become edentulous, OR 2.74 (95% CI 2.12, 3.53) and current smokers more likely than never smokers, OR=2.46 (95% CI 1.74, 3.46).

CONCLUSION: Although more contemporaneous data are needed to determine causality, regular dental utilization and smoking are modifiable factors that could prevent edentulism, even when many other co-morbid conditions are present.

KEY WORDS: edentulism, oral health, longitudinal, dental attendance, smoking

INTRODUCTION

Edentulism is the loss of all natural, permanent teeth. Oral health problems, including tooth loss, affect well-being and the quality of life, such as speaking, smiling, and eating. Pain, infection and inflammation in the mouth that can lead to tooth loss can affect other organ systems and vice versa. In the United States, edentulism prevalence has been decreasing.[1,2] However, in 2009-14, based on NHANES data, edentulism still affected 6.2 million Americans 50 years and older, 17.6% of adults aged 65 and older and 22.5% of those 75 and older. Wide disparities in edentulism exist by poverty status; for example, among those 50 years or older, the prevalence is 6.5% among non-poor individuals compared to 23.4% living in poverty.[1] Many factors have been associated with tooth loss and edentulism prevalence based on cross-sectional studies including sociodemographic factors, residing in rural areas, chronic conditions such as diabetes, health risk behaviors, other health related factors such as poor self-rated general health, physical and functional decline, and oral diseases including periodontitis and untreated dental caries.[3-9] However, cohort-based incidence data for the U.S. population is very limited and not current.[10]

The Health and Retirement Study [11]is an ongoing longitudinal, biennial study of U.S. adults fielded by the University of Michigan's Institute for Social Research. The focus of the HRS, which began in 1992, is to collect data about health and socioeconomic aspects of the lives of the 50 and older population. The sampling scheme of the HRS has a complex design comprised of a panel that not only supports nationally representative estimates, but also oversamples various demographic groups. About 20,000 people have participated with additional cohorts recruited

over time to maintain the sample.[11] The HRS has the advantage of including a large number of health conditions, behaviors, disabilities and functional limitations, though few specific to oral health. A consensus conference conducted by the European Federation of Periodontology (EFP) and the European Organization for Caries Research (ORCA) gave high priority to national oral health surveys with representative samples of older adults to better understand oral disease progression with age, especially given the trends of increases in populations with diabetes, dementia and medication-induced xerostomia, all risk factors for periodontitis and caries, precursors of tooth loss.[12] The purpose of this analysis was to determine factors associated with older adults becoming edentulous over a six-year period in this nationally representative United States sample.

METHODS

Data Source: Health and Retirement Study

We conducted a cohort study using publically available, longitudinal data from the HRS. The HRS data were collected by a combination of face-to-face and telephone interviews, as well as in a few cases for this analysis, physical measures and administrative data linkages. Some questions in the survey were not asked in every 2-year data collection wave and in the case of our primary measure, edentulism, the corresponding question was asked every 3 waves, i.e. every 6 years.

Cohort Selection for Analysis, Inclusion and Exclusion Criteria

Our study aimed to select a cohort to explore the factors associated with the incidence of edentulism between 2006 and 2012. The HRS began collecting data on edentulism in 2006 and at the time of analysis, 2012 was the most recent year for publicly available data on edentulism prevalence. As such, to initialize our cohort, we began with all participants in the 2006 core survey (n=18,469).

Inclusion criteria consisted of being age 50 and older, having a sampling weight in 2006 and 2012, and answering the question about complete tooth loss in 2006 and 2012. Exclusion criteria included already being edentulous in 2006, no valid sampling weight in 2012 (unless one had moved into a nursing home since 2006). Individuals with missing or invalid data on items pertaining to edentulism and other covariates were excluded. For each item in our analysis, no more than 3% of observations had missing data.

Measures

Edentulism Incidence

Edentulism, was defined as self-reporting "Yes" to the question of "Have you lost all of your upper and lower natural permanent teeth?". Of the dentate respondents (those who answered "No" in 2006) we derived a measure of incidence who reported being edentulous by answering "Yes" in 2012.

Demographics, Dental Utilization and Lifestyle

Several 2006 baseline demographic variables were used in the analysis: age, race/ethnicity, marital status, education levels, wealth (quartiles derived from estimation of total assets including second home from RAND's HRS Wealth Imputation file);[13] gender; urban/rural status[14] (Urban = Counties in metro area of 1 million population or more, Suburban = Counties in metro areas of 250,000 to 1 million, Ex-urban = All other levels of Rural-Urban Continuum Code). To summarize measures of employment over the study period, we created the following 3-level categorical variable: working all, some, or none of the study period. A binary variable denoted whether a participant reported being enrolled in Medicaid at any time in the four waves of data collection: 2006, 2008, 2010, and 2012.

We derived a dental utilization variable based on response to the question, "In the last two years, have you seen a dentist for dental care, including dentures?". The "Yes" responses from 2008, 2010 and 2012 were summed (0-3). The derived variable indicated whether one was a "regular attender" and had seen a dentist at least once during all three time periods in the study or was a non-regular attender. This dental attender variable is our best available proxy to measure access to dental care.

Several variables were included that relate to healthy lifestyle factors. Baseline smoking status was categorized as never smoked, past smoker, and current smoker. Alcohol status was defined as an indicator variable denoting respondents reporting "Yes" to "Do you ever drink any alcoholic beverages such as beer, wine, or liquor?" versus those not reporting "Yes". Baseline body mass index (BMI) and change in BMI over study period were calculated from self-reported

measures, but when BMI inputs were missing, physical measurements were used for the few respondents who had available data.

Comorbidities and Functional Status

Other self-reported health measures were considered to determine if they coincided with edentulism incidence. The Selim comorbidity index[15] was used to guide selection of variables. For almost all comorbidities, we categorized each variable as follows: 1) no occurrence of poor health outcome, 2) 2006 baseline poor health status (previous cases); 3) incidence of poor health outcome reported in 2012 (incident cases). Using those criteria, we categorized the following self-reported health conditions: angina, arthritis, blood pressure, cancer, congestive heart failure, diabetes, poor eyesight, heart attack, lung disease, nearsightedness, pain, and stroke. Depression, the only mental health condition included, was coded as an indicator variable for whether an individual reported experiencing any depression at any biennial time point in the 4 data collection periods.

A series of variables were created to convey information about functional status of participants. One set of variables measured mobility, strength, gross motor skills, and fine motor skills[16] which was summarized in the HRS data. A summary score calculated how many of 10 activities a respondent could do. A second set captured a count of Activities of Daily Living (ADLs) a respondent has difficulty or needs help with (Functional Limitations). These five activities included walking, dressing, bathing, getting in/out of bed, and using the toilet. The number of functional limitations in 2006 was collapsed to 0 or $\geq$ 1 limitation(s). Change in functional

limitations over time were categorized as $\leq -1, 0, \geq 1$. (See Supplementary Table S1) We also created a dichotomized measure of self-reported health (excellent/very good/good vs. fair/poor).

Statistical Analysis

The statistical analysis focused on modeling the outcome of incidence of edentulism. Baseline descriptive statistics (frequencies and weighted percentages) comparing the differences between the two groups (edentulous vs dentate) were calculated. Independence between edentulism incidence and baseline variables was tested using Rao–Scott Design-Adjusted Test. We calculated unadjusted odds ratios to measure bivariate association between covariates and edentulism incidence. All statistical analysis, unless specified otherwise, incorporated 2006 sampling weights and complex sampling design (stratification and clustering) into estimates. Statistical significance of odds ratios was assessed using a score test of logistic regression parameter estimates at α=0.05, with joint test used for non-binary categorical predictors.

To build a parsimonious model of factors associated with edentulism, we used a series of multivariable logistic regression models with backwards elimination (α=0.05). The initial model included all the aforementioned demographic variables and the dental attendance variable (Model 1), yielding a concise set of significant predictors. Three additional separate models (Model 2: lifestyle/behaviors, Model 3: functional status, and Model 4: disease incidence) were built to determine significant predictors in the respective domains while adjusting for significant demographic variables and the dental attendance variable. A final backwards elimination algorithm on all variables that remained in all four models was executed. Adjusted odds ratios

and 95% CIs of parameters were obtained from the final logistic regression model. All analyses were completed using SAS 9.4 (SAS Institute, Inc.; Cary, NC).

RESULTS

Participants and Descriptive Data

The steps of the cohort inclusion and exclusion process are summarized in Figure 1. Of those excluded for not having a sampling weight in 2012, 3,279 had died by 2012 and 974 were deemed noninterviews. The final analytic cohort consisted of 9,982 participants, of whom 563 (5%) became edentulous by 2012. The characteristics of participants in 2006 by dentate status in 2012 are shown in Table 1. The overall mean age was 63.4, SE = 0.18. In bivariate analyses summarized in the Supplementary Table S1, the group that became edentulous had a higher proportion of males, older age groups, Black/African Americans, people of lower socioeconomic status (lower wealth, less education, Medicaid enrollment), unemployed, not currently married, with fair/poor self-rated health and non-regular dental attenders (all $p < 0.05$).

Relationship with Dental Visit Attendance

Over half of the cohort, 58%, were regular dental attenders with a dental visit at least once in each of the three two-year time periods, and 42% non-regular attenders. The estimated odds of edentulism was 4.7 times greater for non-regular versus regular attenders, 9.0% and 2.1% respectively (Table 2). Over the six-years, 13% of the non-regular attenders did not report a dental visit at any timepoint, 12% once and 17% twice.

Multivariable Regression Model Building

The variables in each initial and parsimonious model are shown in Table 2. Of the demographic and dental attendance variables in model 1, six variables - education, employment, gender, race/ethnicity, wealth quartile and dental attendance variables - were significant ($p < 0.05$) and were included as adjustment variables in each of the additional models. Age group, marital status, Medicaid enrollment and urban/rural location were not included in the parsimonious model. In model 2, lifestyle variables that remained in that parsimonious model were baseline smoking, alcohol status and change in BMI; baseline BMI did not. In model 3, only baseline self-rated health status remained in the parsimonious model. The variables that did not remain were change in self-rated health, 2006 number of ADLs (0-5), change in number of ADLs, 2006 number (0-10) of and change in functional ADL difficulties. Of the 13 disease incidence variables in model 4, only the incidence of pain and lung disease remained in the parsimonious model.

Variables and estimates for the final regression model are shown in Figure 2 and Supplementary Table S2. Ten variables remained; the education and lung disease variables did not. The strongest relationships based on the size of the ORs, were dental attendance and baseline smoking status. Non-regular dental attenders had almost three times the odds compared to regular attenders of becoming edentulous (OR = 2.74, 95% CI: 2.12, 3.53) and current smokers were more likely than never smokers (OR = 2.46, 95% CI: 1.74, 3.46). Other risk factors were lower wealth, 2006 fair/poor rated health, being Black/African American, having pain, and being

male. BMI increase (OR = 0.97, 95% CI: 0.94, 0.99) was statistically significant but of questionable clinical relevance, and at baseline, being an alcohol drinker was protective compared to being a non-drinker (OR = 0.75, 95% CI: 0.60, 0.92).

DISCUSSION

Edentulism has been associated with poor general health.[17] This longitudinal analysis enabled the assessment of whether multiple demographic factors, dental attendance, lifestyle, functional difficulties or incidence of diseases and comorbid health conditions, were risk or preventive factors for becoming edentulous during the subsequent six years. In our final model, non-regular dental attenders had almost three times the odds of becoming edentulous than regular attenders over the six years. Current smokers had more than twice the odds compared to never smokers. Results from a study of trends in edentulism among Asian American groups in the United States had some similar findings.[18] Based on analyses of cross-sectional 1999-2008 National Health Interview Surveys, higher levels of education and more recent dental check-ups decreased edentulism risk, and smoking increased the risk. A systematic review of the relationship between tooth loss and smoking supported a causal association, even when studies used varying definitions of tooth loss.[19]

Having less wealth, being unemployed, being Black/African American versus White and male were also significant factors associated with edentulism. Socio-economic and racial disparities in tooth loss are well documented.[2] The finding that males had greater odds than females might be related to the higher prevalence of periodontitis among men than women in the U.S.[20] and

lower prevalence of an annual dental visit.[21] In spite of the many baseline prevalence and derived incidence variables of co-morbidities and functional difficulties included in the analysis, they were captured in the final model by baseline self-report of fair/poor health at baseline and incidence of pain, which were both associated with edentulism.

Zhang, Wu and Wu[22] examined the relationship between oral health status and functional decline in the reverse direction. They used oral health data from a 2008 HRS module collected from a subsample of 1,243 individuals to determine if poor oral health preceded a subsequent decline in disabilities in ADLs and instrumental ADLs such as using a telephone, assessed in 2008-2014. Those who reported poor oral health exhibited greater decline in functional status, measured by ADLs and instrumental ADLs even when adjusting for sociodemographics and comorbities. Results indicated that some oral health variables were likely to be confounded by these covariates. The HRS data has the advantage of being able to include and adjust for many of them.[23]

It is not known why baseline alcohol consumption and BMI increase might be protective factors for edentulism. One hypothesis might be that non-drinkers were abstaining because of medical conditions or medications that negatively interact with alcohol, and thus they might be less healthy. Other dietary information was not available to understand what beverages might be consumed instead, such as sugar-sweetened beverages associated with dental caries, one of the precursors of tooth loss. In a cross–sectional analysis using 1999-04 NHANES data of adults

aged 60 and older, light to moderate alcohol use, moderate or greater physical activity and more frequent dental check-ups were associated with maintaining natural teeth.[24]

Limitations

Almost all of the information used was based on self-report. The Selim Comorbidity Index, based on patient self-report has been validated using external measures.[15] Our findings are based on a large sample size, but includes some bias as the participants were required to be available in 2006 and 2012, thus those deceased, too ill, or unwilling to continue HRS participation were excluded. It would have been preferable to have other oral health status information such as number and condition of teeth present in 2006 and year the individual became edentulous, but this information was not collected in the HRS. Similarly, measures of exposure to fluoride and other oral health prevention modalities and access to and preference for complex and costly dental treatment vs. extractions were not available. Furthermore, it is difficult to interpret BMI increase because of lack of temporality in relation to when the person became edentulous and potential effect on diet. The increase could mean the person was getting healthier or sicker.

The study strengths include the many aspects of health assessed, the large sample size, generalizability and representation of the U.S. population.

In summary, although more contemporaneous data are needed to determine causality, regular dental utilization and smoking are modifiable factors that could prevent edentulism, even when many other co-morbid conditions are present.

ACKNOWLEDGMENTS

Financial Disclosure: The University of Michigan Health and Retirement Study's data collection was supported by the National Institute of Aging (grant NIA U01AG009740) and the Social Security Administration.

Conflict of Interest: The authors do not have any financial or personal conflicts to disclose.

Author contributions: The authors made the following contributions: study concept and design (JAW, JAJ, MF), publicly available data was used from the Health and Retirement Study website (https://hrs.isr.umich.edu/documentation), data analysis (PS, BO, CP, JAW), interpretation of data (JAW, BO, JAJ, MF, CP), preparation of manuscript (JAW, BO, JAJ, MF, CP).

Sponsor's role: Not applicable. The authors are solely responsible for the content and the decision to submit the manuscript for publication.

REFERENCES

1. Slade GD, Akinkugbe AA, Sanders AE. Projections of U.S. Edentulism prevalence following 5 decades of decline. J Dent Res 2014;93(10):959-965.
2. Dye BA, Weatherspoon DJ, Lopez Mitnik G. Tooth loss among older adults according to poverty status in the United States from 1999 through 2004 and 2009 through 2014. J Am Dent Assoc 2019;150(1):9-23.e3.
3. Machtei EE, Hausmann E, Dunford R et al. Longitudinal study of predictive factors for periodontal disease and tooth loss. J Clin Periodontol 1999;26:374-380.
4. Peltzer K, Hewlett S, Yawson AE et al. Prevalence of loss of all teeth (edentulism) and associated factors in older adults in China, Ghana, India, Mexico, Russia and South Africa. Int J Environ Res Public Health 2014;11(11):11308-11324. doi: 10.3390/ijerph111111308.
5. Kailembo A, Preet R, Stewart Williams J. Common risk factors and edentulism in adults, aged 50 years and over, in China, Ghana, India and South Africa: results from the WHO Study on global AGEing and adult health (SAGE). BMC Oral Health. 2016;17(1):29. doi: 10.1186/s12903-016-0256-2.
6. Felton DA. Complete Edentulism and Comorbid Diseases: An Update. J Prosthodont 2016;25(1):5-20.
7. Caldwell JT, Lee H, and Cagney KA. The role of primary care for the oral health of rural and urban older adults. J Rural Health 2017;33:409-418.

8. Hassel AJ, Safaltin V, Grill S et al. Risk factors for tooth loss in middle and older age after up to 10 years: An observational cohort study. Arch Oral Biol 2018;86:7-12.
9. Zhang W, Wu YY, Wu B. Does oral health predict functional status in late life? Findings from a national sample. J Aging Health 2018;30(6):924-944.
10. Eklund SA and Burt BA. Risk factors for total tooth loss in the United States; longitudinal analysis of national data. J Public Health Dent. 1994; 54(1) 5-14.
11. University of Michigan Institute for Social Research. HRS Health and Retirement Study. http://hrsonline.isr.umich.edu/ Accessed January 25, 2019.
12. Tonetti MS, Bottenberg P, Conrads G et al. Dental caries and periodontal diseases in the ageing population: call to action to protect and enhance oral health and well-being as an essential component of healthy ageing - Consensus report of group 4 of the joint EFP/ORCA workshop on the boundaries between caries and periodontal diseases. J Clin Periodontol 2017;44 Suppl 18:S135-S144. doi: 10.1111/jcpe.12681.
13. RAND Center for the Study of Aging, with funding from the National Institute on Aging and the Social Security Administration. Santa Monica C. RAND HRS Detailed Imputations File 2014 (V2) (online). 2018 Available from: https://www.rand.org/labor/aging/dataprod/income-wealth-imputation.html Accessed December 2, 2018.
14. Health and Retirement Study. Cross-Wave Geographic Information: Respondent Census Division/Region and Mobility File Data Description. 2016. Available from:

http://hrsonline.isr.umich.edu/modules/meta/xyear/region/desc/HRSXRegionDD_2014.pdf Accessed December 1, 2018.

15. Selim AJ, Fincke BG, Ren XS et al. Comorbidity assessments based on patient report. Results from the Veterans health study. J Ambulatory Care Manage 2004;27(3):281-295.
16. Fonda S, Herzog AR, Wallace RB, Regula A, Mary H, Ofstedal B, et al. HRS/AHEAD Documentation Report Documentation of Physical Functioning Measured in the Health and Retirement Study and the Asset and Health Dynamics among the Oldest Old Study (online). 2004. Available from: http://hrsonline.isr.umich.edu/sitedocs/userg/dr-008.pdf Accessed December 3, 2018.
17. Griffin SO, Jones JA, Brunson D, Griffin PM, Bailey WD. Burden of oral disease among older adults and implications for public health priorities. Am J Public Health 2012;102(3):411-418.
18. Wu B, Liang J, Landerman L, Plassman B. Trends of edentulism among middle-aged and older Asian Americans. Am J Public Health 2013;103(9):e76-82.
19. Hanioka T, Ojima M, Tanaka K, Matsuo K, Sato F, Tanaka H. Causal assessment of smoking and tooth loss: a systematic review of observational studies. BMC Public Health 2011;11:221. doi: 10.1186/1471-2458-11-221.
20. Eke PI, Dye BA, Wei L, Slade GD, Thornton-Evans GO, Borgnakke WS et al.. Update on Prevalence of Periodontitis in Adults in the United States: NHANES 2009 to 2012. J Periodontol 2015;86(5):611-22.

21. Manski RJ, Moeller JF, Maas WR. Dental services: An analysis of utilization over 20 years. J Am Dent Assoc 2001;132(5):655-664.

22. Zhang W, Wu YY, Wu B. Does Oral Health Predict Functional Status in Late Life? Findings from a national sample. J Aging Health 2018;30(6):924-944.

23. Wu B, Liang J, Plassman BL, Remle C, Luo X. Edentulism trends among middle-aged and older adults in the United States: comparison of five racial/ethnic groups. Community Dent Oral Epidemiol 2012;40(2):145-53.

24. Wu B, Liang J, Plassman BL, Remle RC, Bai L. Oral health among white, black, and Mexican-American elders: an examination of edentulism and dental caries. J Pub Health Dent 2011;71(4):308-317.

LEGENDS

Table 1: Characteristics of the Health and Retirement Study (HRS) Cohort at baseline in 2006 by Dentate Status in 2012

Table 2: Variables in each initial and parsimonious model

Figure 1: Selection criteria for Health and Retirement Study (HRS) Participants in Cohort, 2006 and 2012 by Dentate Status

Figure 2: Final Regression Model, Adjusted Odds Ratios, 95% Confidence Intervals and p-values

Legend:

Variable Category

Notes: The x-axis is displayed on the Log10scale. P-values are denoted as: * $p \leq 0.05$, ** $p \leq 0.01$, *** $p \leq 0.001$

Supplemental File:

Supplementary Table S1: Summary of Bivariate Associations between Incident Edentulism and Study Variables

Supplementary Table S2: Final Regression Model, Adjusted Odds Ratios, 95% Confidence Intervals and p-values

Table 1: Characteristics of HRS Cohort at baseline in 2006 by Dentate Status in 2012

2006 Characteristic	Dentate (non-incident cases)		Edentulous (incident cases)		Overall	p-value[a]
Variable	N[b]	Weighted Percent (95% CI)	N[b]	Weighted % (95% CI)	Weighted % (95% CI)	
Age Group						
50-64	4268	62.9 (61.1, 64.7)	216	56.5 (52.0, 61.1)	62.6 (60.8, 64.4)	<.01
65-74	3481	23.8 (22.6, 24.9)	211	25.0 (21.6, 28.4)	23.8 (22.8, 24.9)	
75-84	1435	11.4 (10.2, 12.5)	109	15.4 (11.9, 18.8)	11.6 (10.5, 12.7)	
85+	235	1.9 (1.6, 2.2)	27	3.1 (1.8, 4.4)	2.0 (1.7, 2.3)	
Gender (Male)	3930	45.6 (44.6, 46.5)	263	53.0 (47.2, 58.9)	45.9 (45.0, 46.9)	0.02
Race / Ethnicity						
Non-Hispanic White/Caucasian	7295	82.3 (80.2, 84.4)	335	66.5 (60.6, 72.5)	81.5 (79.3, 83.7)	<.001
Non-Hispanic Black or African American	1119	8.0 (7.0, 8.9)	133	17.4 (13.8, 21.1)	8.4 (7.5, 9.4)	
Hispanic	802	7.2 (5.3, 9.1)	76	11.7 (7.0, 16.4)	7.4 (5.4, 9.5)	
Other	203	2.5 (2.0, 3.1)	19	4.3 (2.1, 6.6)	2.6 (2.1, 3.2)	
Marital Status						
Married	6388	68.7 (67.3, 70.1)	313	59.6 (54.4, 64.8)	68.2 (66.9, 69.6)	0.004
Separated/Divorced	1300	15.5 (14.3, 16.6)	109	20.9 (16.1, 25.7)	15.8 (14.6, 16.9)	
Widowed	1441	11.9 (11.3, 12.5)	125	16.0 (13.2, 18.9)	12.1 (11.5, 12.7)	
Never Married	290	4.0 (3.6, 4.4)	16	3.5 (1.6, 5.4)	3.9 (3.5, 4.3)	
Educational Attainment						
No degree/GED	1713	15.2 (13.7, 16.8)	209	34.0 (28.0, 39.9)	16.2 (14.5, 17.8)	<.001
High School, unknown, Some College	5201	55.0 (53.4, 56.6)	297	52.7 (46.4, 59.0)	54.9 (53.2, 56.6)	
4 year college +	2505	29.8 (27.8, 31.7)	57	13.3 (9.1, 17.5)	28.9 (27.0, 30.9)	
Urbanicity						
Urban	4534	48.8 (43.2, 54.4)	241	41.8 (34.3, 49.3)	48.4 (42.8, 54.0)	0.1
Suburban	2201	22.5 (17.8, 27.2)	145	24.4 (17.1, 31.8)	22.6 (17.9, 27.3)	
Ex-urban	2684	28.7 (24.7, 32.8)	177	33.8 (26.6, 40.9)	29.0 (25.0, 33.0)	
Alcohol Drinker	5327	59.5 (57.7, 61.4)	243	45.0 (40.7, 49.4)	58.8 (57.0, 60.7)	<.001
Smoking Status						
Never Smoked	4465	46.6 (45.2, 48.0)	182	28.6 (23.0, 34.2)	45.7 (44.3, 47.1)	<.001
Past Smoker	3965	41.3 (39.9, 42.6)	245	44.0 (39.8, 48.1)	41.4 (40.0, 42.7)	
Current Smoker	989	12.2 (11.2, 13.1)	136	27.4 (22.9, 32.0)	12.9 (11.9, 14.0)	
Seen Dentist, 1st Wave	7042	77.2 (75.7, 78.7)	288	52.4 (46.7, 58.2)	76.0 (74.5, 77.5)	
Medicaid, 1st Wave	490	4.4 (3.7, 5.2)	80	12.4 (9.1, 15.8)	80.3 (79.0, 81.5)	<.001

Self-Reported Health (Excellent/Very Good/ Good)	7550	81.4 (80.1, 82.7)	344	58.4 (53.0, 63.8)	4.8 (4.1, 5.6)	<.001

[a] Tested using Rao–Scott Design-Adjusted Test for Independence between edentulism incidence and variable.
[b] Unweighted frequencies.

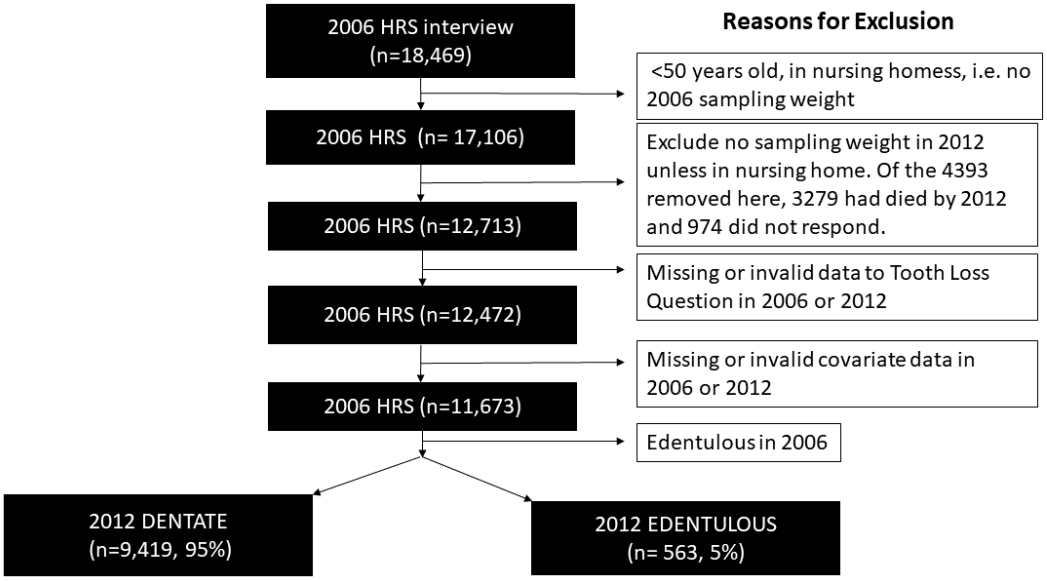
Table 2: Variables in each initial and parsimonious[a] model

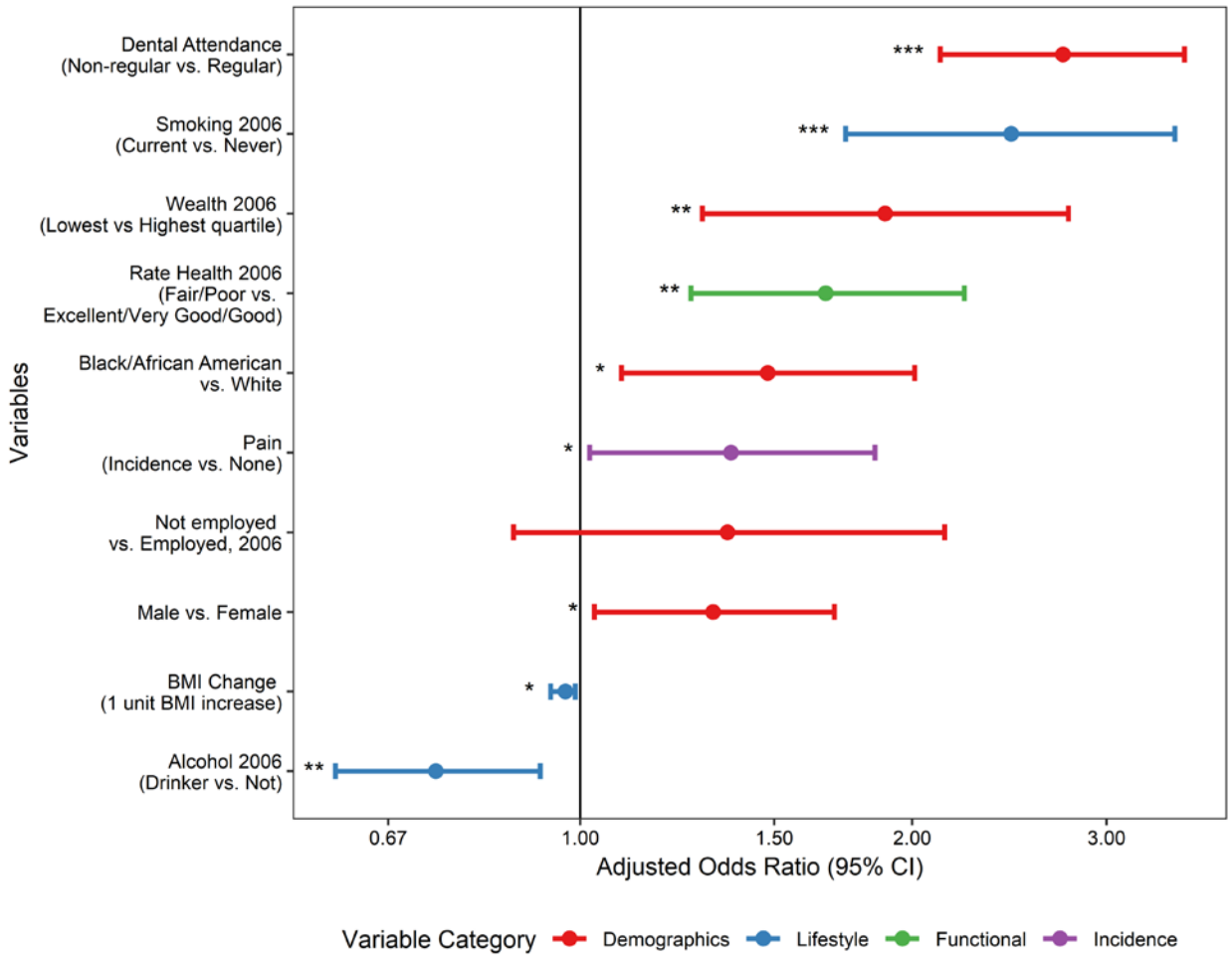
Model 1. Demographics	**Model 2. Lifestyle[b]**	**Model 3. Functional [b]**	**Model 4. Disease Incidence[b]**
Education	**Smoking 2006**	**Rate Health 2006**	**Pain**
Employment	**Alcohol 2006**	Rate Health change	**Lung Disease**
Gender	BMI 2006	# Basic Activities of Daily Living (ADL) 2006 (0-5)	**Angina**
Race/Ethnicity	**BMI Change**	# Basic ADL change	Arthritis
Wealth Quartile		# Functional ADL difficulties 2006 (0-5)	Hypertension
Dental Attendance		# Functional ADL change	Heart Attack
Age Group			Cancer
Marital Status			Congestive Heart Failure
Medicaid			Depression
Urban/Rural			Diabetes
			Worsening Eyesight

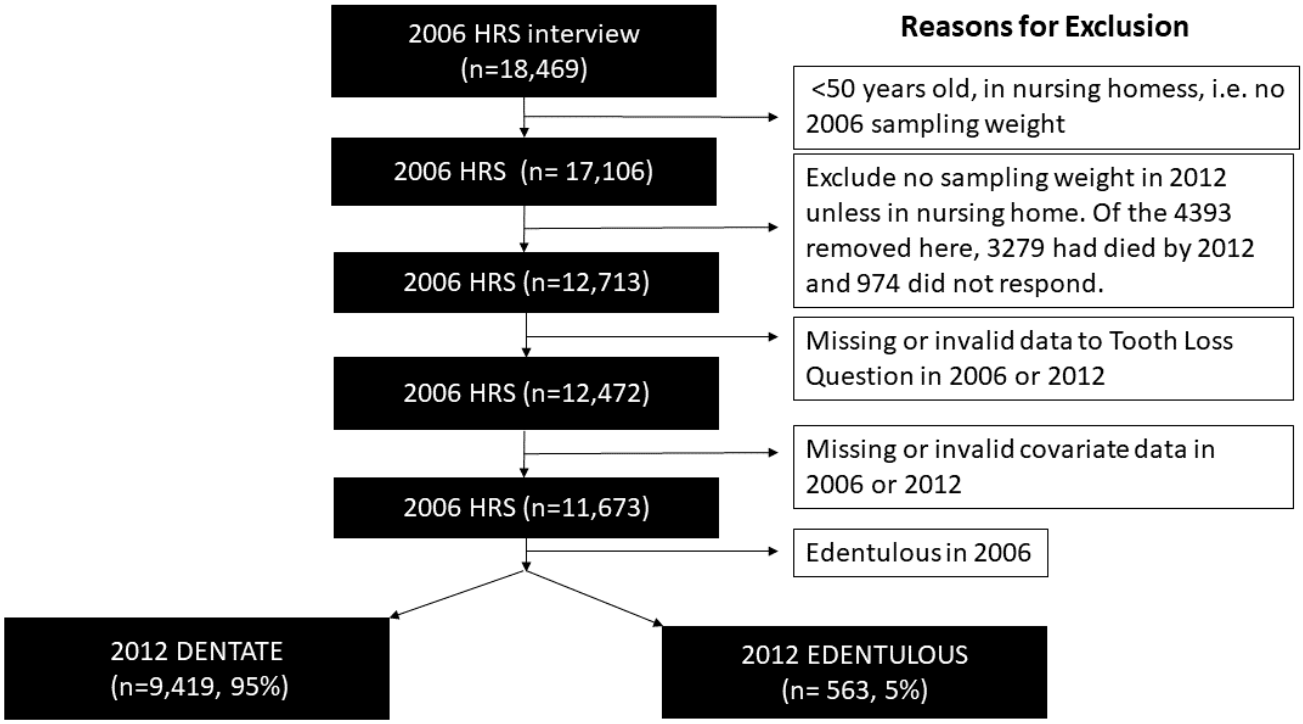
			Worsening Near Vision
			Stroke

[a] Parsimonious variables shown in bold font.

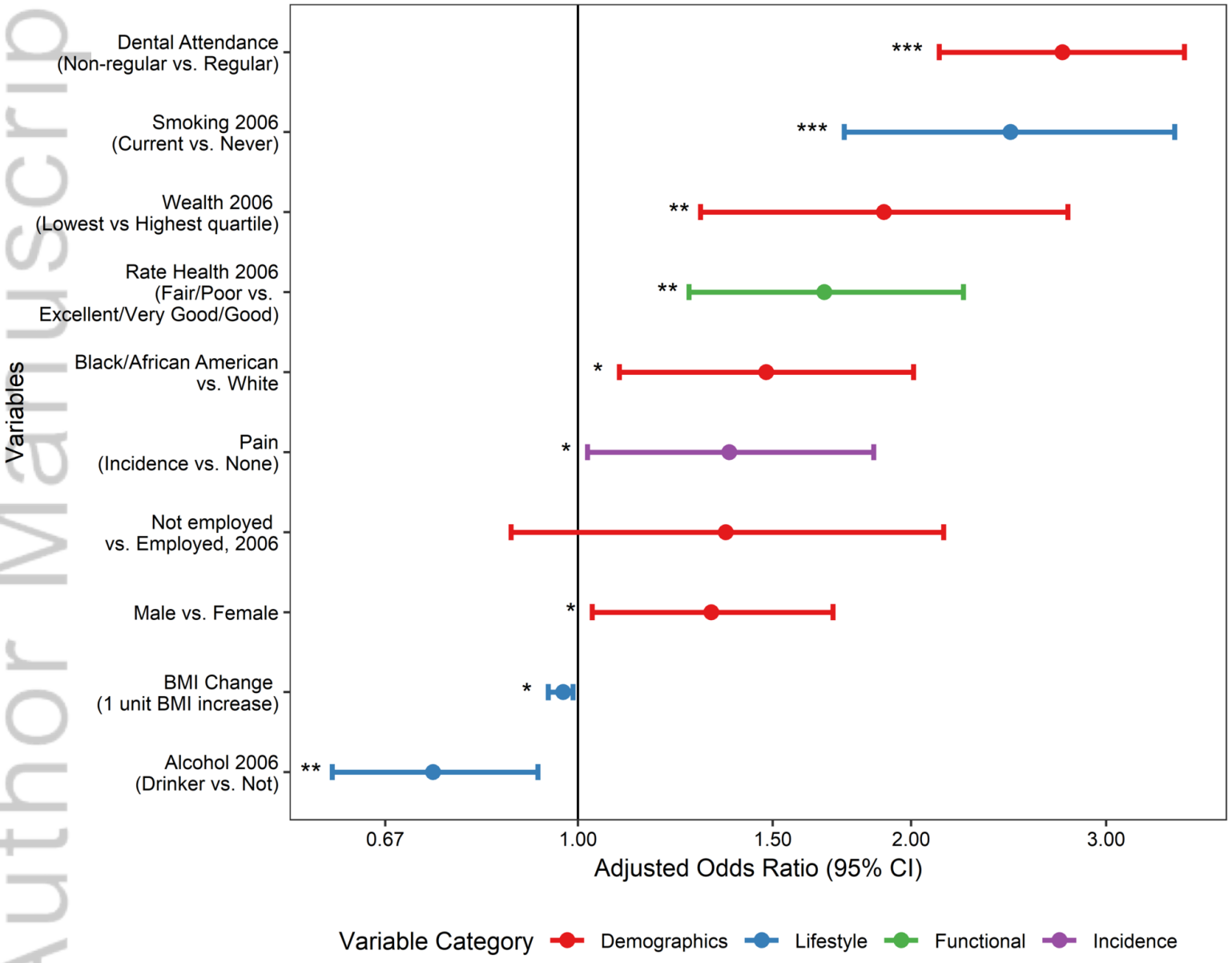
[b] Models 2-4 included the six parsimonious variables in model 1.







JGS_16079_Figure 1 JAGS Edentulism HRS JAW 3-22-19.png



JGS_16079_Figure 2 JAGS-0429 R2 w legend png.png

WILEY

Color Charge Form
Journal of the American Geriatrics Society

Upload this form to your submission OR return it to:
Emily Hammond / JAGS Editorial Office
jags@jjeditorial.com

Dear Author:
If you have supplied color figures in your submission, the first color figure in print is free of cost. Any additional figures you wish to print in color will incur a fee of $500 each. Please indicate how EACH of your figures should be handled in the table below.

INSTRUCTIONS: **For EVERY figure in your paper**, an X should be provided in the appropriate row. Place an '**X**' in **column 1** for a maximum of **ONE figure.** Place an '**X**' in **column 2** if you want to pay for additional color printing. The total in this column should be entered into the Quantity field below.	**Figure No.**	**Color in PRINT (waive fee)**	**Color in PRINT (charge $500 per)***	**Color ONLINE ONLY (no charge)**	**Black/White ONLINE and PRINT**
	1				X
	2	X		X	
	3				
	4				
	5				
	TOTAL:				

***If you indicate ANY figures in this column, the contact information below MUST be provided.**

Please Complete & Please Print

Component(s) in Article	Charge(s)	Quantity	Estimated Charge(s) (in USD)
Color Figure Charge **Standard**	$500 per figure		$0
			$ 0 = Total Estimated

Name: Jane A. Weintraub

Manuscript No.: JAGS-0429

Manuscript Title: **Factors Associated with Becoming Edentulous in the U.S. Health and Retirement Study**

Address: University of North Carolina at Chapel Hill Adams School of Dentistry, 4508 Koury Oral Health Sciences Building, Campus Box 7450, Chapel Hill, NC 27599-7450

Phone Number:919-537-3240

Fax Number:

Email Address: Jane_Weintraub@unc.edu

Verify your agreement to pay by signing and dating below. Wiley will send an invoice to the email address you've provided:

There is no charge. Signature:_____

_____Date:___6/24/19_____