Factors Associated With Becoming Edentulous in the US Health and Retirement Study

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

DESIGN: Longitudinal study over a 6-year period.

SETTING: United States, 2006, 2012.

PARTICIPANTS: Nationally representative US sample of adults, aged 50 years and older (n = 9982), participating in the Health and Retirement Study 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 and 2012 of comorbid medical conditions, functional limitations, and disabilities.

RESULTS: From 2006 to 2012, 563 individuals (5%) became edentulous and 9419 (95%) remained dentate. Adults who became edentulous by 2012 were more likely than those who remained dentate to be black/African American compared to white, to be less educated, were current smokers, had diabetes, and reported poorer self-rated general health, more functional limitations and disabilities, and fewer dental visits (all $P < .0001$), among other factors. Of those with regular dental visits (at least once every 2 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. Nonregular dental attenders were more likely than regular attenders to become edentulous (odds ratio [OR] = 2.74; 95% confidence interval [CI] = 2.12-3.53), and current smokers were more likely than never smokers to become edentulous (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 comorbid conditions are present. **J Am Geriatr Soc 67:2318-2324, 2019.**

Key words: dental attendance; edentulism; longitudinal; oral health; smoking

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, from 2009 to 2014, based on National Health and Nutrition Examination Survey (NHANES) data, edentulism still affected 6.2 million Americans aged 50 years and older, 17.6% of adults aged 65 years and older, and 22.5% of those aged 75 years and older. Wide disparities in edentulism exist by poverty status; for example, among those aged 50 years or older, the prevalence is 6.5% among nonpoor 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

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

DOI: 10.1111/jgs.16079

0002-8614/19/$15.00

decline; and oral diseases, including periodontitis and untreated dental caries.[3-9] However, cohort-based incidence data for the US population are limited and not current.[10]

The Health and Retirement Study (HRS)[11] is an ongoing longitudinal, biennial study of US 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 population aged 50 years and older. The sampling scheme of the HRS has a complex design composed of a panel that not only supports nationally representative estimates, but also oversamples various demographic groups. Approximately 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, although few are specific to oral health. A consensus conference conducted by the European Federation of Periodontology and the European Organization for Caries Research 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 6-year period in this nationally representative US sample.

METHODS

Data Source: Health and Retirement Study

We conducted a cohort study using publicly 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 three waves (ie, 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 aged 50 years 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 and 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 of 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] sex, and urban/rural status[14] (urban = counties in metropolitan area of ≥1 million population, suburban = counties in metropolitan 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 three-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 2 years, have you seen a dentist for dental care, including dentures?" The "yes" responses from 2008, 2010, and 2012 were summed (range = 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 nonregular 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?" vs 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), and (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 four data collection periods.

A series of variables was 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 were 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 1 or more limitation(s). Change in functional limitations over time was categorized as -1 or less, 0, or 1 or more (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 the Rao–Scott Design-Adjusted Test. We calculated unadjusted odds ratios (ORs) 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 ORs was assessed using a score test of logistic regression parameter estimates at $\alpha = .05$, with joint test used for nonbinary categorical predictors.

To build a parsimonious model of factors associated with edentulism, we used a series of multivariable logistic regression models with backwards elimination ($\alpha = .05$). 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 ORs and 95% confidence intervals (CIs) of parameters were obtained from the final logistic regression model. All analyses were completed using SAS 9.4 (SAS Institute, Inc).

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, 3279 had died by 2012 and 974 were deemed noninterviews. The final analytic cohort consisted of 9982 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) years. In bivariate analyses summarized in Supplementary Table S1, the group who became edentulous had a higher proportion of males, older age groups, blacks/African Americans, people of lower socioeconomic status (lower wealth, less education, Medicaid enrollment), unemployed, not currently married, with fair/poor self-rated health and nonregular dental attenders (all $P < .05$).

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 2-year time periods, and 42% were nonregular attenders. The estimated odds of edentulism was 4.7 times greater for nonregular vs regular attenders (9.0% vs 2.1%) (Table 2). Over the 6 years, 13% of the nonregular attenders did not report a dental visit at any time point, 12% once and 17% twice.

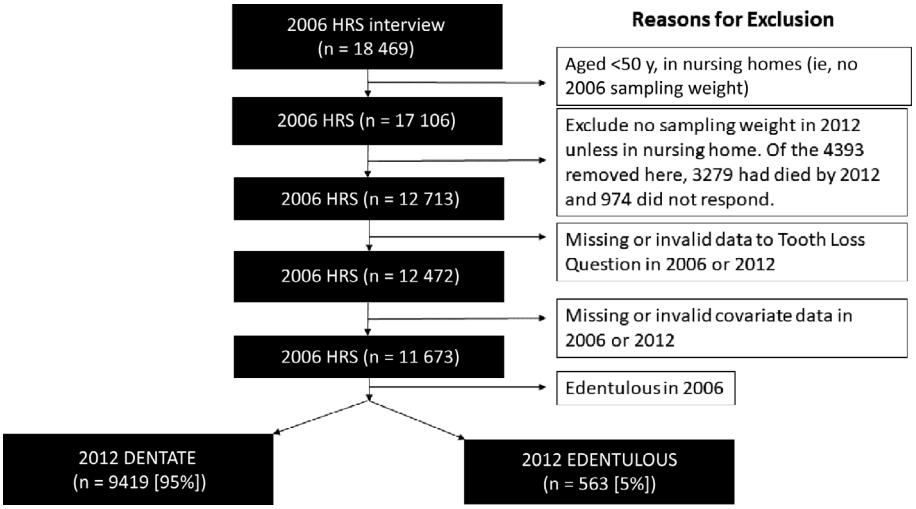

Figure 1. Selection criteria for Health and Retirement Study (HRS) participants in cohort, 2006 and 2012 by dentate status.

Table 1. Characteristics of HRS Cohort at Baseline in 2006 by Dentate Status in 2012

2006 Characteristic	Dentate (nonincident cases)		Edentulous (incident cases)		Overall weighted % (95% CI)	*P* value[a]
	No.[b]	Weighted % (95% CI)	No.[b]	Weighted % (95% CI)		
Age group, y						
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)	
Male sex	3930	45.6 (44.6-46.5)	263	53.0 (47.2-58.9)	45.9 (45.0-46.9)	.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)	.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-y College or more	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)	.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, first wave	7042	77.2 (75.7-78.7)	288	52.4 (46.7-58.2)	76.0 (74.5-77.5)	
Medicaid, first 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

Abbreviations: CI, confidence interval; GED, general equivalency diploma; HRS, Health and Retirement Study.
[a]Tested using Rao–Scott Design-Adjusted Test for Independence between edentulism incidence and variable.
[b]Unweighted frequencies.

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, sex, race/ethnicity, wealth quartile, and dental attendance variables) were significant ($P < .05$) 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 remain in the model. 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 (range = 0-5), change in number of ADLs, 2006 number of ADLs (range = 0-10), 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. Nonregular 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 nondrinker (OR = 0.75; 95% CI = 0.60-0.92).

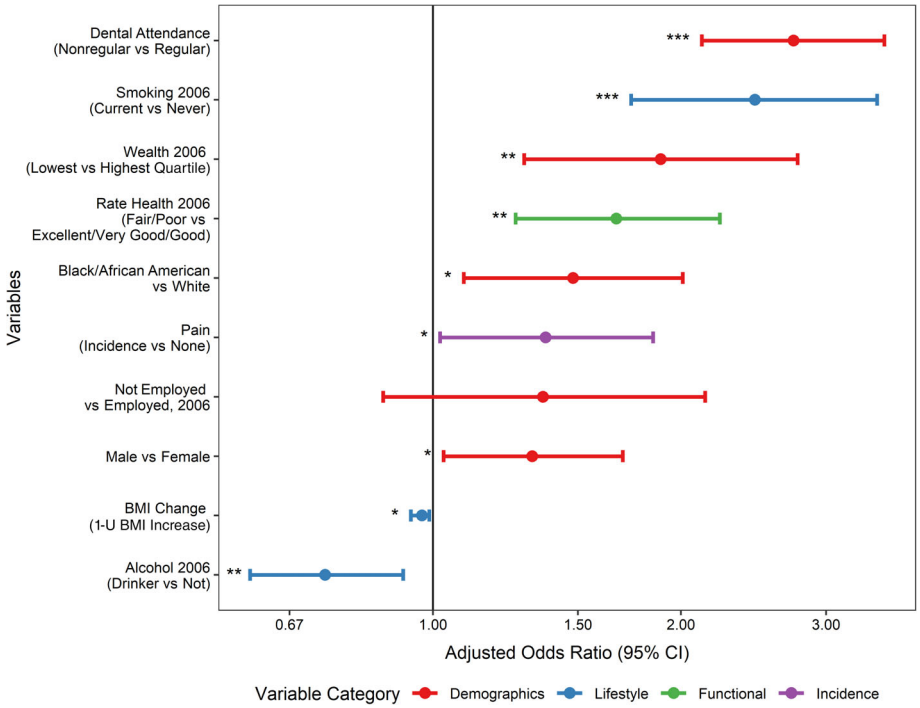

Figure 2. Final regression model, adjusted odds ratios, 95% confidence intervals (CIs), and *P*-values. Variable category is shown. The *x* axis is displayed on the log10 scale. *P* values are denoted as: $*P \le .05$, $**P \le .01$, $***P \le .001$. BMI indicates body mass index.

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 was a risk or preventive factor for becoming edentulous during the subsequent 6 years. In our final model, nonregular dental attenders had almost three times the odds of becoming edentulous than regular attenders over the 6 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 to 2008 National Health Interview Surveys, higher levels of education and more recent dental checkups 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 vs white, and being male were also significant factors associated with edentulism. Socioeconomic 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 United States[20] and lower prevalence of an annual dental visit.[21] Despite the many baseline prevalence and derived incidence variables of comorbidities 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 et al.[9] 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 1243 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 to 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 comorbidities. Results indicated that some oral health variables were likely to be confounded by these covariates. The HRS data have the advantage of being able to include and adjust for many of them.[22]

It is not known why baseline alcohol consumption and BMI increase might be protective factors for edentulism. One hypothesis might be that nondrinkers 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 to 2004 NHANES data of adults aged 60 years and older, light to moderate alcohol use, moderate or greater physical activity, and more frequent dental checkups were associated with maintaining natural teeth.[23]

Limitations

Almost all 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 they include some bias as the participants were required to be available in 2006

Table 2. Variables in Each Initial and Parsimonious Model

Model 1: demographics	Model 2: lifestyle[a]	Model 3: functional[a]	Model 4: disease incidence[a]
Education	**Smoking 2006**	**Rate health 2006**	**Pain**
Employment	**Alcohol 2006**	Rate health change	**Lung disease**
Sex	BMI 2006	Number of basic ADLs 2006 (range = 0-5)	**Angina**
Race/ethnicity	**BMI change**	Number of basic ADLs change	Arthritis
Wealth quartile		Number of functional ADL difficulties 2006 (range = 0-5)	Hypertension
Dental attendance		Number of functional ADLs change	Heart attack
Age group			Cancer
Marital status			Congestive heart failure
Medicaid			Depression
Urban/rural			Diabetes
			Worsening eyesight
			Worsening near vision
			Stroke

Abbreviations: ADL, activity of daily living; BMI, body mass index.
Note: Parsimonious variables shown in boldfaced font.
[a]Models 2 through 4 included the six parsimonious variables in model 1.

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 US 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 comorbid 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 (J.A.W., J.A.J., M.F.), publicly available data were used from the Health and Retirement Study website (https://hrs.isr.umich.edu/documentation), data analysis (P.S., B.O., C.P., J.A.W.), interpretation of data (J.A.W., B.O., J.A.J., M.F., C.P.), preparation of manuscript (J.A.W., B.O., J.A.J., M.F., C.P.).

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

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SUPPORTING INFORMATION

Additional Supporting Information may be found in the online version of this article.

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.