Cognitive Function and Oral Health Among Community-Dwelling Older Adults

By: Bei Wu, Brenda L Plassman, Richard J Crout, and Jersey Liang

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Summary:

Both oral health problems and cognitive impairment are relatively common among older adults. Poorer oral health appears to contribute to a decline in quality of life and to be related to various medical conditions. Little is known about the relationship of cognitive function to oral health among community-dwelling older adults. The sample included 1984 dentate community-dwelling older adults 60 years old or older from the National Health and Nutrition Examination Survey (NHANES, 1999-2002) who completed both the study cognitive measure and dental examination. Weighted descriptive and multivariate regression analyses were performed. Multivariate analyses showed that cognitive function was associated with oral health. Individuals with lower cognitive scores had a higher number of decayed and missing teeth and a higher proportion of periodontitis sites. The predicted number of decayed teeth increased by 0.01 with each 1-point decrease in the Digit Symbol Substitution Test score; the number of missing teeth increased by 0.02; and the percentage of sites with periodontal disease increased by 0.02. In addition, individuals' sociodemographic characteristics, health behavior, and regular dental checkups were significantly associated with oral health. This study suggests that community-dwelling elders with lower cognitive function scores have greater deterioration of oral health. This study provides a preliminary knowledge base for the development of early intervention strategies to address oral health problems among older adults.

Abstract:

Background. Both oral health problems and cognitive impairment are relatively common among older adults. Poorer oral health appears to contribute to a decline in quality of life and to be related to various medical conditions. Little is known about the relationship of cognitive function to oral health among community-dwelling older adults.

Methods. The sample included 1984 dentate community-dwelling older adults 60 years old or older from the National Health and Nutrition Examination Survey (NHANES, 1999-2002) who completed both the study cognitive measure and dental examination. Weighted descriptive and multivariate regression analyses were performed.

Results. Multivariate analyses showed that cognitive function was associated with oral health. Individuals with lower cognitive scores had a higher number of decayed and missing teeth and a higher proportion of periodontitis sites. The predicted number of decayed teeth increased by 0.01 with each 1-point decrease in the Digit Symbol Substitution Test score; the number of missing teeth increased by 0.02; and the percentage of sites with periodontal disease increased by 0.02. In addition, individuals' sociodemographic characteristics, health behavior, and regular dental checkups were significantly associated with oral health.

Conclusions. This study suggests that community-dwelling elders with lower cognitive function scores have greater deterioration of oral health. This study provides a preliminary knowledge base for the development of early intervention strategies to address oral health problems among older adults.

Key Words: Cognitive function-Oral health-Older adults.

Article:

ORAL health is a critical and often overlooked component of an older adult's health and well-being (1-6). Evidence from clinical samples suggests that elderly persons have an increased incidence of oral disease and that the frequency of oral health problems increases significantly in cognitively impaired older adults, primarily those with dementia. The few studies to examine the relationship between cognitive function and oral health have primarily focused on patients with Alzheimer's disease (AD) or other dementias. Results from three longitudinal studies have consistently shown higher rates of oral conditions such as salivary dysfunction (7,8), coronal and root caries (2,3,9), and other oral diseases (2,3) in individuals with dementia compared to nondemented controls. These findings involving individuals with diagnosed dementia may not apply to older individuals across the full range of cognitive function, including the large number of persons with undiagnosed dementia (10) or with cognitive impairment not severe enough to meet criteria for dementia (11). To address this point, a few studies have investigated the association between cognitive status and oral health in later life. These studies provide preliminary support for an association between performance on brief cognitive status measures and poorer oral health based on the presence of more decayed teeth (1), greater dental functional impairment (6), and a trend toward more coronal and root caries (12). However, interpretation of these studies has been limited by the use of cognitive measures insensitive to the full range of cognitive ability, inability to control for key variables associated with oral health, or a small sample size.

The present study addresses a number of the limitations of the previous studies and builds on their findings in examining the link between cognitive function and oral health among community-dwelling older adults in the following ways: (i) the use of a cognitive measure sensitive to performance spanning the adult cognitive range and the inclusion of individuals with a spectrum of cognitive abilities (from individuals with potential dementia to cognitively normal); (U) the application of multivariate analyses to more comprehensively examine the relationship between cognitive function and oral health while controlling for important covariates such as sociodemographic characteristics, physical health, dental care utilization, and dental insurance; and (iii) the use of a large, nationally representative data set.

METHODS

Data Source

This study used the National Health and Nutrition Examination Survey (NHANES, 1999-2002), a population-based survey designed to collect information on the health and nutrition of the U.S. population. The NHANES used a stratified, multistage, clustered sampling design to obtain a representative sample of the noninstitutionalized civilian U.S. population. Data were collected during inhome interviews and dental and health examinations conducted in mobile examination centers. Beginning in 1999, the NHANES became a continuous annual survey rather than a periodic one. Currently, all relevant data for 1999-2002 are available for public use.

Sample Population

The sample included dentate individuals (i.e., with at least one tooth), 60 years old or older, who were administered the cognitive test and who completed at least one oral health examination. Edentulous individuals were not included because they had no periodontitis or decayed teeth. Due to differences in the number of individuals who completed each part of the oral health examination, the sample size for decayed and missing teeth models was 1984 and 1463 for the periodontal disease model. A total of 521 individuals did not undergo the periodontal examinations because of exclusionary chronic conditions.

Measures

Dependent variables.-The status of oral health was based on a clinical examination by a study dentist. All dental examiners and back-up examiners underwent the same rigorous training and calibration prior to the data collection. Kappa values estimating inter-rater and intra-rater reliability for the examinations ranged from 0.70 to 1.00 (13). Examinations were based on a maximum of 28 teeth and 56 periodontal sites per individual. Third molars were excluded because of their frequent extraction. Caries status was determined by the number of

decayed teeth. Missing teeth was defined as the number of teeth missing. Periodontal disease was defined as the percentage of permanent tooth sites with ≥4 mm probing depth (14-16).

Table 1. Sample Characteristics: Dentate Individuals Aged ≥60 Years* (Weighted)

	Full Sample (N = 1984)*	Subsample† (N = 1463)
	Mean/ Percentage (SE)	Mean/ Percentage (SE)
Cognitive function score (0–117)	48.82 (0.58)	49.46 (0.64)
Sociodemographics		
Age (range 60–85)	70.22 (0.31)	69.51 (0.24)
Female	54.58 (0.91)	48.53 (1.31)
Education		
Less than high school	23.52 (1.40)	35.95 (1.26)
High school	27.58 (1.32)	23.58 (1.11)
More than high school	48.90 (1.74)	40.46 (1.28)
Race		
White	83.95 (1.83)	56.94 (1.30)
Black	6.48 (1.02)	14.63 (0.92)
Hispanic	6.98 (1.39)	26.11 (1.15)
Other	2.59 (0.72)	2.32 (0.39)
Dental coverage	36.90 (2.20)	40.05 (1.28)
Health status		
Diabetes	12.70 (0.80)	15.65 (0.95)
High blood pressure	49.20 (1.22)	47.44 (1.31)
Heart disease	17.51 (1.34)	12.51 (0.87)
Stroke	4.83 (0.51)	4.85 (0.56)
Lung disease	14.08 (1.01)	11.07 (0.82)
ADL and IADL score (range 0–8)	0.80 (0.04)	0.69 (0.04)
Health behaviors		
Light/moderate drinker	38.78 (2.63)	36.77 (1.26)
Current smoker	9.24 (0.94)	9.98 (0.78)
Health Eating Index (0–100)	68.05 (0.44)	67.94 (0.51)
Dental care utilization		
Routine checkups		
Two or more times a year	33.49 (2.40)	39.58 (1.28)
Once a year	3.50 (0.52)	3.55 (0.48)
Less than once a year	17.97 (1.23)	19.07 (1.03)
Whenever needed, no regular schedule	45.04 (2.44)	37.80 (1.27)
Oral health status		
Mean No. of decayed teeth (range 0–28)	0.43 (0.05)	0.41 (0.05)
No Decayed teeth	81.43 (0.98)	83.63 (1.38)
1–2 Decayed teeth	13.45 (0.61)	11.90 (0.97)
3–4 Decayed teeth	2.72 (0.28)	2.58 (0.53)
5+ Decayed teeth	2.4 (0.09)	1.89 (0.41)
Mean No. of missing teeth (range 0–28)	8.25 (0.23)	8.09 (0.23)
No Missing teeth	11.51 (1.00)	11.56 (1.20)
1–5 Missing teeth	34.37 (0.61)	36.51 (1.03)
6–10 Missing teeth	21.46 (0.51)	21.25 (1.34)
11+ Missing teeth	32.66 (0.36)	30.68 (1.40)
Percentage of sites with probing depth ≥4 mm	—	1.10 (0.12)
Percentage of individuals with at least one site with probing depth ≥4 mm	—	15.21 (1.09)

Notes: *Individuals 60 years old or older who had at least one tooth.
†Based on individuals who underwent periodontal examinations (N = 1463).
SE = standard error; ADL = activities of daily living; IADL = instrumental activities of daily living.

Table 1. ***Sample Characteristics: Dentate Individuals Aged ≥60 Years* (Weighted)***

Independent variables.-Cognitive performance was measured using the Digit Symbol Substitution Test (DSST) (17), which primarily assesses psychomotor performance, but sustained attention, response speed, visuomotor coordination, and incidental memory all contribute to performance on this measure. The DSST is highly sensitive to any type of brain dysfunction and discriminates well between mild dementia and normal cognition (18). The DSST was used as a continuous variable and was scored between O and 117 in the study sample (see Table 1).

Covariates

Sociodemographics.-We included age (measured in years), gender (female = 1), marital status (married/living with partner = 1), dummy variables for blacks and Hispanics (with whites and other races combined as the reference group), level of education (1 = less than high school, 2 = high school, and 3 = some college or above), income measured by Poverty Income Ratio, and dental insurance coverage (having coverage = 1).
Physical health.-Physical health problems were defined as reported functional impairment or presence of diabetes, heart disease, lung disease, high blood pressure, or stroke. Functional impairment was defined as self-reported limitations in activities of daily living (ADL) and instrumental activities of daily living (IADL). ADLs include eating, dressing, walking, and getting in and out of bed. IADLs include managing money, doing household chores, preparing meals, and shopping. The presence of any reported limitations was coded as 1, O otherwise. A summary of ADL and IADL limitations combined was created by adding 1 point for each of the eight limited activities.

Health behaviors.-We included three health behaviors: past and current smoking (smoking = 1), alcohol consumption, and diet. Alcohol consumption was coded as self-reported light/moderate drinker (between 12 alcoholic drinks in the past 12 months and fewer than 2 alcoholic drinks per day) and heavy drinker was coded as 2 alcoholic drinks per day in the previous 12 months (19). Diet was analyzed by using the Healthy Eating Index (HEI) score. The HEI score is the sum of 10 components, each representing different aspects of a healthy diet and each having a score from O to 10. An HEI score >80 implies a "good" diet; 51-80 a diet that "needs improvement"; <51 a "poor" diet (20).

Dental care utilization.-One self-reported variable, "frequency of regular checkups," was coded as an ordinal variable where 1 - whenever needed or no regular schedule, 2 = less than once a year, 3 = once a year, and 4 = 2 or more times a year.

Analysis

We used SAS 9.1 (SAS Institute, Gary, NC) for all analyses, PROC SURVEY procedures were used to take into account the weights provided in the data set yielding unbiased standard error estimates. In the tables, sample sizes were unweighted. However, estimates for means, proportions, and standard errors were weighted. PROC SURVEYREG was used to perform general linear regression models on three dependent variables: decayed teeth, missing teeth, and periodontal diseases. To determine the separate contributions of sociodemographic characteristics, cognitive function, physical health, health behaviors, and dental care utilization, a hierarchical block design was used in regression analyses. The first step included the cognitive function measure and sociodemographic characteristics. The second step added physical health and health behaviors, and the third step added regular dental checkups. Of the medical conditions noted under "Physical Health" above, only those conditions that were significantly related to at least one of the three oral health outcomes in bivariate analyses were included in the models. In addition, exploratory analysis showed that the variables "past smoker" and "heavy drinker" were not significantly associated with the three outcome variables and therefore were not included in the final models. Income was highly correlated with level of education (r - 0.51) and was not included in the analyses.

Table 2. Regression Analysis Results for Decayed Teeth ($N = 1984$) (Weighted)

	Model 1	Model 2	Model 3
	b (*SE*)	b (*SE*)	b (*SE*)
DSST score	−0.01 (0.00)*	−0.01 (0.00)*	−0.01 (0.00)‡
Sociodemographics			
Age	−0.01 (0.01)‡	−0.01 (0.01)	−0.01 (0.01)
Female	−0.18 (0.07)‡	−0.21 (0.08)‡	−0.19 (0.08)‡
Education	−0.23 (0.08)†	−0.20 (0.08)‡	−0.13 (0.07)
Black	0.36 (0.18)	0.34 (0.17)	0.24 (0.18)
Hispanic	−0.09 (0.13)	−0.09 (0.12)	−0.18 (0.12)
Dental coverage	−0.05 (0.08)	−0.03 (0.08)	0.03 (0.08)
Health status and behaviors			
Diabetes		0.10 (0.11)	−0.00 (0.10)
Congestive heart failure		−0.27 (0.18)	−0.35 (0.19)
Heart attack		−0.10 (0.09)	−0.14 (0.09)
Emphysema		0.50 (0.35)	0.41 (0.33)
High blood pressure		−0.05 (0.06)	0.00 (0.07)
ADL and IADL score		−0.01 (0.02)	−0.01 (0.02)
Light/moderate drinker		−0.27 (0.08)†	−0.18 (0.06)‡
Current smoker		0.20 (0.15)	0.14 (0.16)
Healthy Eating Index (HEI)		0.00 (0.00)	−0.00 (0.00)
Dental care utilization			
Routine checkups			−0.26 (0.04)*
r^2	0.06	0.07	0.12

Notes: *$p < .001$.
†$p < .01$.
‡$p < .05$.
SE = standard error; DSST = Digit Symbol Substitution Test; ADL = activities of daily living; IADL = instrumental activities of daily living.

Table 2. ***Regression Analysis Results for Decayed Teeth (N = 1984) (Weighted)***

RESULTS

Table 2 shows the results of the regression models for the number of decayed teeth. In the fully specified model (Model 3), the predicted number of decayed teeth increased by 0.01 with each 1-point decrease in DSST score. This model explained 12% of the variance for decayed teeth.

Lower cognitive function was strongly associated with an increased number of missing teeth (Table 3). The impact of cognitive function on missing teeth decreased after adding physical health and routine checkups into the model. The predicted number of missing teeth increased by 0.02 with each 1-point reduction in DSST score. This model explained 19% of the variance for missing teeth.

Similar to other oral health outcomes, cognitive function was significantly related to periodontal diseases (Table 4). A lower cognitive performance score was associated with an increased percentage of sites with periodontal disease. The impact of cognitive function on periodontal disease remained stable after adding routine checkups to the model. With each 1-point reduction in DSST score, the predicted percentage of sites with periodontal disease increased by 0.02. This model explained 6% of the variance for periodontal disease.

DISCUSSION

The present study showed that, across the spectrum of cognitive function as measured by DSST, as scores got lower, individuals' oral health status got progressively worse, after controlling for several key variables, such as age, gender, and race that are often associated with performance on cognitive measures. These findings extend those from previous studies showing oral health deterioration among individuals with cognitive impairment, AD, or other types of dementia. In addition, the impact of cognitive function on oral health decreased somewhat

after controlling for covariates such as regular dental checkups. Furthermore, this study extended beyond the limitations of previous studies by using data from a national probability sample that captures a full range of cognitive function among community-dwelling elders 60 years old or older.

Table 3. Regression Analysis Results for Missing Teeth ($N = 1984$) (Weighted)

	Model 1	Model 2	Model 3
	b (*SE*)	b (*SE*)	b (*SE*)
DSST score	−0.05 (0.01)*	−0.04 (0.01)†	−0.02 (0.01)‡
Sociodemographics			
Age	0.02 (0.03)	0.04 (0.03)	0.05 (0.03)
Female	0.39 (0.35)	0.50 (0.35)	0.60 (0.35)
Education	−2.23 (0.32)*	−2.01 (0.31)*	−1.67 (0.30)*
Black	2.23 (0.50)*	1.97 (0.56)†	1.47 (0.58)‡
Hispanic	0.91 (0.80)	0.95 (0.76)	0.50 (0.74)
Dental coverage	−0.31 (0.37)	−0.11 (0.37)	0.20 (0.38)
Health status and behaviors			
Diabetes		1.03 (0.59)	0.51 (0.54)
Congestive heart failure		0.47 (0.84)	0.11 (0.87)
Heart attack		0.77 (0.88)	0.55 (0.83)
Emphysema		2.47 (1.03)‡	2.03 (0.94)†
High blood pressure		0.30 (0.27)	0.50 (0.28)
ADL and IADL score		−0.07 (0.14)	−0.08 (0.15)
Light/moderate drinker		−1.03 (0.32)†	−0.59 (0.32)
Current smoker		3.05 (1.09)†	2.76 (0.95)†
Healthy Eating Index (HEI)		−0.03 (0.02)	−0.01 (0.02)
Dental care utilization			
Routine checkups			−1.26 (0.17)*
r^2	0.12	0.15	0.19

Notes: *$p < .001$.
†$p < .01$.
‡$p < .05$.
SE = standard error; DSST = Digit Symbol Substitution Test; ADL = activities of daily living; IADL = instrumental activities of daily living.

Table 4. Regression Analysis Results for Periodontitis ($N = 1463$) (Weighted)

	Model 1	Model 2	Model 3
	b (*SE*)	b (*SE*)	b (*SE*)
DSST score	−0.03 (0.008)*	−0.02 (0.01)*	−0.02 (0.01)*
Sociodemographics			
Age	−0.07 (0.02)*	−0.06 (0.02)*	−0.06 (0.02)*
Female	−0.59 (0.20)*	−0.55 (0.21)†	−0.53 (0.20)†
Education	−0.20 (0.17)	−0.19 (0.20)	−0.12 (0.20)
Black	1.41(0.92)	1.38 (0.92)	1.28 (0.93)
Hispanic	0.46 (0.65)	0.50 (0.68)	0.40 (0.68)
Dental coverage	−0.44 (0.25)	−0.41 (0.25)	−0.34 (0.26)
Health status and behaviors			
Diabetes		0.37 (0.54)	0.27 (0.52)
Congestive heart failure		−0.64 (0.35)	−0.72 (0.36)
Heart attack		0.09 (0.60)	0.06 (0.59)
Emphysema		−0.55 (0.51)	−0.64 (0.51)
High blood pressure		0.03 (0.22)	0.08 (0.21)
ADL and IADL score		0.10 (0.10)	0.10 (0.09)
Light/moderate drinker		0.16 (0.26)	0.26 (0.24)
Current smoker		0.45 (0.69)	0.39 (0.69)
Healthy Eating Index (HEI)		−0.01 (0.01)	−0.01 (0.01)
Dental care utilization			
Routine checkups			−0.26 (0.09)*
r^2	0.05	0.05	0.06

Notes: *$p < .01$.
†$p < .05$.
SE = standard error; DSST = Digit Symbol Substitution Test; ADL = activities of daily living; IADL = instrumental activities of daily living.

Table 3. ***Regression Analysis Results for Missing Teeth (N = 1984) (Weighted)***
Table 4. ***Regression Analysis Results for Periodontitis (N = 1463) (Weighted)***

Cognitive decline is common among older adults and is often an early sign of a progressive dementing disorder such as AD. Although we are not able to distinguish between individuals whose low cognitive score represents a decline from previous ability and those with lifelong low cognitive function, the implications of these findings may be the same regardless of the underlying cause of the low cognitive score. The risk of poorer oral health status increases as an individual's score on cognitive function decreases. The present results may underestimate the extent of the association between cognitive function and oral health because the sample likely did not include the more severely impaired individuals. Among the NHANES sample of individuals 60 years old or older, 731 (of 3706) did not complete the cognitive measure and therefore were excluded from the present study. For many individuals, the DSST may not have been completed due to significant cognitive impairment or dementia. In addition, among those excluded individuals, the scores for edentulous individuals who completed the DSST test were much lower than those for individuals in the study sample.

This study, along with many previous studies, has shown that an individual's socioeconomic status (as represented by years of education) is strongly related to oral health. It is possible that the association between cognitive function and oral health observed here, even after controlling for education, still may reflect unmeasured differences in lifecourse socioeconomic status. Cognitive function may reflect not only level of educational attainment but also the quality of education and cumulative effect of socioeconomic status (e.g., previous or current occupational status, wealth, and cognition in childhood) across the life span (21-23).

Dental care utilization likely serves as a mediating variable between cognitive function and oral health. As indicated from previous studies (24), this study found that dental care utilization had a strong association with all three oral health outcomes. We recently reported that cognitive function has a significant impact on dental care utilization (25). Individuals with lower cognitive function may not view dental care as a high priority and

may have limited self-awareness of dental care needs. In addition, a decline in cognition may be reflected as a decline in IADL performance, specifically a decline in the quality and regularity of oral hygiene. These changes may partially explain the association between cognition and oral health. This hypothesis needs to be tested using longitudinal data, as does the idea of reciprocal linkages between oral health and dental care utilization.

Individuals included in the study sample are most likely healthier than those excluded, who had significantly poorer oral health, were significantly older, had a lower level of education, and higher prevalence of chronic conditions such as diabetes, stroke, and heart disease. A similar trend was found for those who were edentulous or did not complete the dental examination for other reasons. In addition, older adults with severe chronic conditions more likely reside in institutions and thus were excluded from NHANES. These factors may have affected the impact of chronic conditions on oral health in the present analyses.

Study Limitations

There are some limitations inherent in the survey data. Due to the cross-sectional nature of the data, we cannot fully tease apart the causal relationship between cognitive function and oral health. We are aware that the linkage between the two is complex. Many of the observed oral health problems may have occurred earlier in life, and decline in oral health may have been a precursor of cognitive decline (26). However, deterioration of oral health is also common among older adults. Some research has suggested that the number of caries in older people over time exceeded that reported from cohort studies of adolescents; in addition, periodontal disease leading to tooth loss can also be rapid in elderly persons (27,28). Therefore, we cannot rule out the possibility that cognitive impairment precipitated the deterioration of oral health. Another limitation is that the DSST, the single cognitive test available in NHANES, only evaluated a segment of the multiple domains that contribute to cognitive ability. Age was top-coded at 85 years; (i.e., all individuals 85 years old or older are coded as 85 years old) therefore, no data are available for individuals older than 85. Other factors, such as genetic factors, depression, and social support, may be important covariates for oral health but were not in the data. The low r^sup 2^, particularly for the periodontal disease models, may be in part due to unspecified factors that were not available for this study.

Future longitudinal studies need to further explore the casual relationship between cognitive function and oral health. Additional measures are also needed to more comprehensively assess cognitive function.

Conclusion

Our findings suggest that community-dwelling elders with low cognitive function are at risk for poor oral health. Our findings provide a knowledge base from which to develop preventive strategies for early intervention to address oral health problems among older adults. If longitudinal data confirm the causal relationship between cognition and oral health, then early detection of deteriorating oral health in relation to cognitive function could have a profound impact on development of appropriate and effective interventions. This could then (i) assist in maintaining good oral health among individuals with mild cognitive impairment, (ii) assist patients and caregivers in making adjustments in oral care patterns, and (iii) help dental care professionals be more proactive in assisting patients with referrals and develop oral health programs to promote practical preventive strategies.

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