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Does Oral Health Predict Functional Status in Late Life? Findings From a National Sample

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Abstract

Objective: This study aims to examine the association between oral health and the decline in functional status among middle-aged and older adults in the United States.

Method: Generalized estimation equation (GEE) Poisson regression models with robust standard errors were used to analyze the longitudinal panel data (2008–2014) from the Health and Retirement Study ($N = 1,243$). Oral health was evaluated using self-rated oral health, poor mouth condition, and tooth loss. Decline in functional status was assessed by disabilities in activities of daily living (ADLs) and instrumental activities of daily living (IADLs).

Results: Respondents with poor oral health were more likely to experience decline in ADLs/IADLs. Adjusting for sociodemographics and comorbidities attenuated the effects of oral health.

Discussion: Findings suggest that oral health might be one of the important predictors of functioning decline in late life, after adjusting sociodemographics and comorbidities.

Keywords

oral health; functional status; disability

Introduction

The increasing life expectancy makes many older adults inevitably experience a decline in functional status at some point in their life. Therefore, it is essential to identify risk factors that may contribute to functional disabilities in late life. Over the past two decades, a growing number of studies have started to document that oral health, an integral part of individual general health and quality of life (Lee, Wu, & Plassman, 2013; Petersen & Yamamoto, 2005; Sheiham, 2005), has a significant impact on frailty, disabilities, and mortality (Holm-Pedersen, Schultz-Larsen, Christiansen, & Avlund, 2008; Torres et al., 2015; Tsakos, Watt, Rouxel, de Oliveira, & Demakakos, 2014; Wu, Fillenbaum, Plassman, & Guo, 2016; Yu, Lai, Cheung, & Kuo, 2011).

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Due to the following major reasons, oral health is important in understanding functional status. First, increasing evidence suggests that oral health is related to systemic diseases, such as cardiovascular diseases (Lockhart et al., 2012; Oliveira, Watt, & Hamer, 2010; Syrjälä, Ylöstalo, Hartikainen, Sulkava, & Knuuttila, 2010; Tonetti & Van Dyke, 2013), diabetes (Luo et al., 2015; Taylor & Borgnakke, 2008), and cognitive impairment (Kaye et al., 2010; Stein, Desrosiers, Donegan, Yepes, & Kryscio, 2010; Stein, Kryscio, Desrosiers, Donegan, & Gibbs, 2010; Wu et al., 2016) that affect functional decline. Studies also indicate that poor oral health will lead to poor dietary intake and malnutrition (Nowjack-Raymer & Sheiham, 2003; Sheiham et al., 2001; Torres et al., 2015) as well as inflammatory responses (Desvarieux et al., 2003; Torres et al., 2015) associated with oral infections. Chronic inflammation, in turn, is associated with low physical function (Brinkley et al., 2009). So, oral diseases and poor mouth condition may be indicators of accelerated aging, and their causal relationship with decline in functional status deserves a close scholarly attention.

However, only a handful studies have directly examined the association between oral health and physical functioning among community-dwelling older adults utilizing longitudinal data. Using a regional sample in Copenhagen, Denmark, one study (Holm-Pedersen et al., 2008) found that tooth loss is related to the follow-up onset of mobility disability among older adults. Several studies conducted in Japan revealed that tooth loss is associated with greater risk of functional disability (Aida et al., 2012; Komiyama et al., 2016) as well as decline in higher level functional capacity (Sato et al., 2016) among older Japanese adults. Using the English Longitudinal Study of Ageing, another study (Tsakos et al., 2014) showed that total tooth loss (edentulousness) is independently associated with physical decline among English older adults. It is unclear whether findings from these longitudinal studies are generalizable to the U.S. population, thus a further study is warranted.

A review of literature on oral health and functional status shows substantial diversity across studies with regard to study design as well as data and sample sources. Most previous studies cited above only used tooth loss as a predictor. This work aims to continue efforts along this line using a large longitudinal data set that contains a nationally representative sample of community-dwelling middle-aged and older adults in the United States. Moreover, we aim to examine whether oral health predicts functional decline after controlling for a wide range of covariates, including individual demographic characteristics, socioeconomic status, and comorbidities. In this study, oral health was comprehensively evaluated using three indicators: self-rated oral health, a composite score measuring problems with oral health such as teeth/gums sensitivity and gums bleeding (defined collectively as *poor mouth condition*), and tooth loss (Hybels et al., 2016).

Method

Data

We used four waves of panel data (2008–2014) from the Health and Retirement Study (HRS; Sonnega et al., 2014) to examine the relationship between multiple indicators of oral health and decline in functional status. The HRS is a nationally representative longitudinal study of middle-aged and older adults above age 50 in 23,000 households in the United

States. The study began in 1992 and subjects were interviewed every 2 years. The HRS is based on a multistage area probability sampling design involving geographical stratification and clustering. Since 2006, the HRS has started to adopt a mixed-model design for follow-ups. In this design, half of the sample is randomly assigned to an enhanced face-to-face interview with physical and biological measures, a psychosocial questionnaire, and the core HRS interview. Another half of the sample completes only the core interview through telephone. An oral health module was included in the 2008 survey and administered to a random subsample of the HRS participants. A total of 1,414 adults completed the oral health module. Among them, approximately 1,243 respondents who completed at least one of the following three waves (2010, 2012, and 2014) were included in the analyses. Response rate ranged from 86% to 89% across four waves. Analyses were performed on all available data. Missing data were not imputed to avoid potential bias (Fitzmaurice, Laird, & Ware, 2011).

Measures

Dependent variables.—Dependent variables of this study included disabilities in activities of daily living (ADLs) and disabilities in instrumental activities of daily living (IADLs). A modified Katz ADL scale (Katz, Downs, Cash, & Grotz, 1970) was used. Respondents were asked whether they had difficulty in completing the following five tasks: bathing, eating, dressing, walking across a room, and getting in or out of bed. A sum score of ADLs was calculated separately for the four waves from 2008 to 2014. Based on the summed scores, the dependent variable, decline in ADLs was further dichotomized into a dummy variable to contrast those with increasing number of disabilities (yes = 1) to those with the same or fewer number of disabilities (no = 0) compared with the previous wave. The number of observations in the three follow-up waves (2010, 2012, and 2014) was 1,218, 1,109, and 993, respectively.

Another dependent variable, IADLs, was a modified Lawton IADL scale (Lawton & Brody, 1969). It was assessed by asking respondents whether they had difficulty in using a telephone, taking medication, handling money, shopping, and preparing meals. Similar to the ADLs measure, a sum score of IADLs was calculated separately for the four waves from 2008 to 2014. And based on the summed scores, decline in IADLs was dichotomized to contrast those with increasing number of IADL disabilities (yes = 1) to those with the same or fewer number of IADL disabilities (no = 0) compared with the previous wave.

Focal independent variables.—Three variables in the oral health module at the baseline were used to evaluate respondents' oral health conditions (Hybels et al., 2016). The first variable was self-rated oral health where the respondents were asked to describe the overall condition of their mouth and teeth using categories of poor, fair, good, or very good. Responses (range = 1–4) were coded such that higher score reflects better self-rated oral health. The second variable was the overall mouth condition, a composite score determined by averaging responses (1 = *never*, 2 = *hardly ever*, 3 = *occasionally*, 4 = *very often*, and 5 = *often*) to three questions: (a) how often they had avoided particular foods because of problems with their teeth, mouth, or dentures; (b) how often their teeth or gums had felt sensitive to hot, cold, or sweets; and (c) how often their gums had bled when they brushed their teeth. The third variable was tooth loss which was measured by three filter questions.

Respondents were first asked whether they had lost more than two natural permanent teeth (respondents who answered *no* were coded as dentate). Respondents who answered *yes* to losing more than two permanent teeth were then asked whether they had lost all teeth from their upper jaw and lower jaw. Respondents who had lost all teeth in both the upper and lower jaw were coded as edentulous and the rest were coded as losing more than two teeth but not full mouth of teeth.

Covariates.—All covariates were measured at the baseline wave in 2008 as we aimed to use baseline characteristics to predict decline in ADLs and IADLs at later waves. The first set of covariates included demographic variables age (50–64, 65–74, 75–84, and 85), gender (male = 1, female = 0), race/ethnicity (White, Hispanic, and Black, with White being the reference group) and marital status (married or partnered = 1, alone = 0). The second set of covariates were indicators of socioeconomic status, including educational attainment (<high school, high school or general education, 1–3 years of college, and 4-year college or more) and household income (US\$0–25,000, US\$25,000–50,000, US\$50,000–75,000, US\$75,000–150,000, and >US\$150,000). Finally, an index of comorbidities (as having chronic health conditions such as high blood pressure, diabetes, cancer, chronic lung disease, heart disease, stroke, emotional/nervous/psychiatric problems, and arthritis) that are likely to be associated with both oral health and functional status (Bailey et al., 2004; Ní Chróinín et al., 2016). The waves (2010, 2012, and 2014) were also adjusted in the analysis to examine the changing trend.

Analysis.—Descriptive statistics (frequency, percentage, mean, standard deviation, etc.) of all variables were reported for the overall sample and for the subsamples by decline in ADLs or IADLs. Generalized estimation equation (GEE) Poisson regression models (Liang & Zeger, 1986; McNutt, Wu, Xue, & Hafner, 2003; Zeger, Liang, & Albert, 1988; Zhang & Yu, 1998; Zou, 2004) with robust standard errors were used to estimate the relative risks (RRs) associated with decline in ADLs/IADLs. We reported the RRs and 95% confidence intervals (CIs) obtained from the model estimated robust standard errors. Exchangeable correlation structure was used to account for subject level repeated measures. The Level 1 variable was participants and Level 2 was the repeated measures nested under each participant. We first calculated crude RR using the bivariate GEE model for each dependent variable and results are summarized in Table 2. Following this, we computed adjusted RRs by including the focal independent variable (self-rated oral health, mouth condition, or tooth loss) and covariates in the sequential models (Models 1–3). For example, for tooth loss as the independent variable, Model 1 added the index of comorbidities. Model 2 replaced comorbidities with sociodemographic variables. And Model 3 incorporated all the covariates. Three oral health variables were examined independently and results are summarized in Tables 3 to 5. All statistical analyses were performed using statistical software R Version 3.2.3.

Results

Descriptive statistics that summarize the characteristics of the overall sample as well as the subsamples by decline in ADLs and IADLs are shown in Table 1. At baseline, more than 28% of the respondents reported their overall oral health being fair or poor. Approximately

15% of the respondents reported that they had poor mouth condition occasionally, often, or very often. When numbers of teeth were examined, around 15.5% of the respondents were edentulous (i.e., lost all their teeth). A majority of sampled respondents were female (59.8%), unmarried (66.4%), and White (78.6%). Almost 54% of the respondents had at least college level of education and over a quarter of the respondents had household income more than 75,000. The average age of the sample was 69 with a standard deviation of 10. Respondents reported having an average of two chronic conditions with a standard deviation of 1.5.

Bivariate results from the GEE models are displayed in Table 2. The bivariate models (the crude models) in Table 2 show that oral health were associated with decline in ADLs; those who reported worse overall oral health, poorer mouth condition, or missing more than two teeth, and those edentulous had significantly higher risks of decline in ADLs in the following years. The bivariate models also show that those having decline in ADLs were more likely to be older, Blacks (compared with Whites), and unmarried, and to have lower levels of education and income and higher levels of comorbidities. No difference by gender was found. Similar patterns were identified for IADLs.

As presented in Table 3, effects of self-rated oral health on decline in ADLs remained significant and substantial regardless of inclusion of either comorbidities or sociodemographics or both in Models 1 to 3. For instance, adjusting for comorbidities in Model 1, those who reported poor or fair oral health showed higher risks of decline in ADLs ($RR = 1.86$, 95% $CI = [1.35, 2.58]$ and $RR = 1.43$, 95% $CI = [1.08, 1.89]$, respectively) compared with those who reported very good oral health. When all covariates were adjusted in the final model (Model 3), those who reported poor oral health still showed higher risks of decline in ADLs ($RR = 1.58$, 95% $CI = [1.13, 2.21]$) compared with those reporting very good oral health. When IADLs was examined, similar results were found with one exception. When all covariates were adjusted in the final model, the effects of self-rated oral health were no longer statistically significant.

Similarly, when mouth condition was examined (Table 4), its effects on decline in ADLs remained significant and substantial regardless of inclusion of either comorbidities or sociodemographics or both in Models 1 to 3. Adjusting for comorbidities in Model 1, those who reported having poor mouth condition very often/often showed higher risks of decline in ADLs ($RR = 1.82$, 95% $CI = [1.24, 2.68]$) compared with those who reported never having poor mouth condition. In the final model (Model 3), the effects of mouth condition remained significant and substantial. However, when IADLs was examined, mouth condition lost its significance in the final fully adjusted model.

Results in Table 5 show that those who had lost all their teeth or had lost more than two teeth reported significantly higher risks of ADLs decline compared with those who had fewer than two teeth lost ($RR = 1.82$, 95% $CI = [1.33, 2.51]$ and $RR = 1.49$, 95% $CI = [1.14, 1.95]$) while adjusting for comorbidities. When controlling for sociodemographics, the effects of tooth loss remained significant for ADLs but lost significance for IADLs. The effects of tooth loss diminished when all covariates were simultaneously added in the final model for both ADLs and IADLs.

Discussion

Using four waves of data across 8 years from the HRS, we examined the effect of oral health at the baseline on the decline in functional status at later waves. Results show that poor oral health indicated by worse self-rated oral health, worse mouth condition, and tooth loss was significantly associated with higher risks of decline in ADLs and IADLs. These associations were strong and substantial as they persisted with an adjustment of either sociodemographics or comorbidities or both. However, with all covariates being included in the final adjusted model, effects of some oral health variables attenuated substantially, suggesting that variables such as income and comorbidities might be important confounding factors linking both oral health and decline in functional status.

To date, very few studies have been conducted to assess the relationship between oral health and decline in functional status. Our study indicates that poor oral health may be a predictor of onset of physical disabilities. Identifying this association is significant because of the following reasons. First, this study focuses on community-dwelling middle-aged and older adults rather than institutionalized elderly (Shimazaki et al., 2001) or elderly with specific chronic conditions such as diabetes mellitus (Huang, Chan, & Young, 2013). This makes our findings more generalizable to the general population of older adults in the United States. Second, in this study, oral health was evaluated using multiple measures and at least two of these measures were found to have independent effects on decline in functional status, ADLs in particular, despite controlling for both sociodemographics and comorbidities in the fully adjusted models. As a result, our findings are in a general agreement with evidence from longitudinal studies conducted in England (Tsakos et al., 2014), Denmark (Holm-Pedersen et al., 2008), and Japan (Aida et al., 2012; Komiyama et al., 2016; Sato et al., 2016), three of which, however, used regional samples.

Our findings also suggest several important confounders that might link to both poor oral health and functional status. As speculated in the previous studies (Komiyama et al., 2016; Sato et al., 2016), poor oral health would affect dietary intake because of the decline in chewing ability (Ikebe et al., 2011; Nowjack-Raymer & Sheiham, 2003; Sheiham et al., 2001) that indirectly affects muscle strength and physical function. Most importantly, poor oral health may also reflect accumulated effects of infection, which is associated with many chronic conditions, including, but are not limited to, cardiovascular disease (Demmer & Desvarieux, 2006; Genco, Offenbacher, & Beck, 2002; Kholy, Genco, & Van Dyke, 2015), diabetes, and cognitive impairment, which in turn, would negatively affect functional status. Compared with the bivariate results in Table 2, Model 1 of Tables 3 to 5 shows that the effects of oral health variables attenuated after the index of comorbidities was included in the model. This finding, to some extent, suggests that the association between oral health and decline in ADLs/IADLs is likely to be confounded by comorbidities.

In addition, some important sociodemographic variables, such as age and income, are also likely to be major confounders for the associations. Including them in the adjusted models, RRs attenuated considerably for the oral health indicators. Our study highlights the importance of socioeconomic status, primarily income levels, in linking both oral health and physical functioning. Adults with higher levels of income may have more alternative food

options to compensate for malnutrition due to chewing difficulties. They can also afford costly treatment procedures such as root canal or tooth implant to maintain chewing ability. By contrast, low socioeconomic status and lack of dental insurance, for instance, are often major barriers that may delay or constrain dental care for socially disadvantaged groups (Nasseh & Vujicic, 2014).

This study has several limitations. First, measures of oral health are based on self-reports rather than clinical oral examinations. This may introduce response biases by social desirability; however, self-reported number of teeth is a well-established and reliable measure (Pitiphat, Garcia, Douglass, & Joshipura, 2002). Future studies should apply more refined clinical oral health measures such as tooth number and periodontal diseases to further evaluate the robustness of the focal associations. In addition, due to the limitation of data, only sociodemographics and comorbidity are included in our study as the major confounders. With more variables on diet/nutrition and inflammation to be incorporated in the surveys, future studies can better evaluate the robustness of the association between oral health and functional status. Third, the follow-up period of this study was relatively short. More study waves across longer period of time may allow chronic conditions and physical disabilities to unfold, resulting stronger associations between oral health measures and physical functioning.

Despite these limitations, this study benefits from a longitudinal study design on a large national sample of middle-aged and older adults in the United States, as well as an inclusion of multiple measures of oral health status and some key covariates. Our results show that oral health indicated by poor self-rated oral health, poor mouth condition, and tooth loss is significantly associated with decline in functional status in the follow-up years, and comorbidities and economic conditions are the important confounders linking the two. These findings suggest that poor oral health may be considered as an antecedent of other chronic conditions as well as an important early indicator of decline in physical functioning. If this is the case, efforts should be made to raise awareness of oral health and oral health knowledge among older adults, families, and health care providers. In addition, dental care should be integrated with medical care so that preventive care and early interventions can be implemented within the clinical settings. Policy makers should also work to increase the dental insurance coverage so that children and adults are able to engage in regular dental checkups to maintain oral health and to delay the onset of oral diseases in late life. Taken together, our study suggests that promoting oral health should be considered as an integrated part of prevention strategies that reduce the incidence of disabilities and health care cost in late life.

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References

- Aida J, Kondo K, Hirai H, Nakade M, Yamamoto T, Hanibuchi T, ... Watt RG (2012). Association between dental status and incident disability in an older Japanese population. *Journal of the American Geriatrics Society*, 60, 338–343. [PubMed: 22211817]
- Bailey RL, Ledikwe JH, Smiciklas-Wright H, Mitchell DC, & Jensen GL (2004). Persistent oral health problems associated with comorbidity and impaired diet quality in older adults. *Journal of American Dietetic Association*, 104, 1273–1276.
- Brinkley TE, Leng X, Miller ME, Kitzman DW, Pahor M, Berry MJ, ... Nicklas BJ (2009). Chronic inflammation is associated with low physical function in older adults across multiple comorbidities. *Journal of Gerontology: Medical Sciences*, 64A, 455–461.
- Demmer RT, & Desvarieux M (2006). Periodontal infections and cardiovascular disease: The heart of the matter. *Journal of American Dental Association*, 137(Suppl.), 14s–20s.
- Desvarieux M, Demmer RT, Rundek T, Boden-Albala B, Jacobs DR, Papapanou PN, & Sacco RL (2003). Relationship between periodontal disease, tooth loss, and carotid artery plaque: The Oral Infections and Vascular Disease Epidemiology Study (INVEST). *Stroke*, 34, 2120–2125. [PubMed: 12893951]
- Fitzmaurice GM, Laird NM, & Ware JH (2011). *Applied longitudinal analysis* (2nd ed.). Hoboken, NJ: John Wiley.
- Genco R, Offenbacher S, & Beck J (2002). Periodontal disease and cardiovascular disease: Epidemiology and possible mechanisms. *Journal of American Dental Association*, 133(Suppl.), 14s–22s.
- Holm-Pedersen P, Schultz-Larsen K, Christiansen N, & Avlund K (2008). Tooth loss and subsequent disability and mortality in old age. *Journal of the American Geriatrics Society*, 56, 429–435. [PubMed: 18194226]
- Huang DL, Chan KC, & Young BA (2013). Poor oral health and quality of life in older U.S. adults with diabetes mellitus. *Journal of the American Geriatrics Society*, 61, 1782–1788. [PubMed: 24001058]
- Hybels CF, Bennett JM, Landerman LR, Liang J, Plassman BL, & Wu B (2016). Trajectories of depressive symptoms and oral health outcomes in a community sample of older adults. *International Journal of Geriatric Psychiatry*, 31, 83–91. [PubMed: 25962827]
- Ikebe K, Matsuda K, Kagawa R, Enoki K, Yoshida M, Maeda Y, & Nokubi T (2011). Association of masticatory performance with age, gender, number of teeth, occlusal force and salivary flow in Japanese older adults: Is ageing a risk factor for masticatory dysfunction? *Archives of Oral Biology*, 56, 991–996. [PubMed: 21529776]
- Katz S, Downs TD, Cash HR, & Grotz RC (1970). Progress in development of the index of ADL. *The Gerontologist*, 10, 20–30. [PubMed: 5420677]
- Kaye EK, Valencia A, Baba N, Spiro A III, Dietrich T, & Garcia RI (2010). Tooth loss and periodontal disease predict poor cognitive function in older men. *Journal of the American Geriatrics Society*, 58, 713–718. [PubMed: 20398152]
- Kholy KE, Genco RJ, & Van Dyke TE (2015). Oral infections and cardiovascular disease. *Trends in Endocrinology & Metabolism*, 26, 315–321. [PubMed: 25892452]
- Komiyama T, Ohi T, Miyoshi Y, Murakami T, Tsuboi A, Tomata Y, ... Hattori Y (2016). Association between tooth loss, receipt of dental care, and functional disability in an elderly Japanese population: The Tsurugaya Project. *Journal of the American Geriatrics Society*, 64, 2495–2502. [PubMed: 27801931]
- Lawton MP, & Brody EM (1969). Assessment of older people: Self-maintaining and instrumental activities of daily living. *The Gerontologist*, 9(3, Pt. 1), 179–186. [PubMed: 5349366]
- Lee K, Wu B, & Plassman BL (2013). Cognitive function and oral health-related quality of life in older adults. *Journal of the American Geriatrics Society*, 61, 1602–1607. [PubMed: 24028360]
- Liang KY, & Zeger SL (1986). Longitudinal data analysis using generalized linear models. *Biometrika*, 73, 13–22.
- Lockhart PB, Bolger AF, Papapanou PN, Osinbowale O, Trevisan M, Levison ME, ... Baddour LM (2012). Periodontal disease and atherosclerotic vascular disease: Does the evidence support an

- independent association? A scientific statement from the American Heart Association. *Circulation*, 125, 2520–2544. [PubMed: 22514251]
- Luo H, Pan W, Sloan F, Feinglos M, & Wu B (2015). Forty-year trends of tooth loss among American adults with and without diabetes mellitus: An age-period-cohort analysis. *Preventing Chronic Disease*, 12(e221), 1–11. doi:10.5888/pcd12.150309
- McNutt LA, Wu C, Xue X, & Hafner JP (2003). Estimating the relative risk in cohort studies and clinical trials of common outcomes. *American Journal of Epidemiology*, 157, 940–943. [PubMed: 12746247]
- Nasseh K, & Vujicic M (2014). The effect of growing income disparities on U.S. adults' dental care utilization. *The Journal of the American Dental Association*, 145, 435–442. [PubMed: 24789236]
- Ní Chroínín D, Montalto A, Jahromi S, Ingham N, Beveridge A, & Foltyn P (2016). Oral health status is associated with common medical comorbidities in older hospital inpatients. *Journal of American Geriatric Society*, 64, 1696–1700.
- Nowjack-Raymer R, & Sheiham A (2003). Association of edentulism and diet and nutrition in US adults. *Journal of Dental Research*, 82, 123–126. [PubMed: 12562885]
- Oliveira CD, Watt R, & Hamer M (2010). Toothbrushing, inflammation, and risk of cardiovascular disease: Results from Scottish Health Survey. *British Medical Journal*, 340, 10.1136/bmj.c2451
- Petersen PE, & Yamamoto T (2005). Improving the oral health of older people: The approach of the WHO Global Oral Health Programme. *Community Dentistry and Oral Epidemiology*, 33, 81–92. [PubMed: 15725170]
- Pitiphat W, Garcia RI, Douglass CW, & Joshipura KJ (2002). Validation of self-reported oral health measures. *Journal of Public Health Dentistry*, 62, 122–128. [PubMed: 11989207]
- Sato Y, Aida J, Kondo K, Tsuboya T, Watt RG, Yamamoto T, ... Osaka K (2016). Tooth loss and decline in functional capacity: A prospective cohort study from the Japan Gerontological Evaluation Study. *Journal of the American Geriatrics Society*, 64, 2336–2342. [PubMed: 27613339]
- Sheiham A (2005). Oral health, general health and quality of life. *Bulletin. World Health Organization*, 83, 644.
- Sheiham A, Steele JG, Marcenes W, Lowe C, Finch S, Bates CJ, ... Walls AW (2001). The relationship among dental status, nutrient intake, and nutritional status in older people. *Journal of Dental Research*, 80, 408–413. [PubMed: 11332523]
- Shimazaki Y, Soh I, Saito T, Yamashita Y, Koga T, Miyazaki H, & Takehara T (2001). Influence of dentition status on physical disability, mental impairment, and mortality in institutionalized elderly people. *Journal of Dental Research*, 80, 340–345. [PubMed: 11269726]
- Sonnega A, Faul JD, Ofstedal MB, Langa KM, Phillips JW, & Weir DR (2014). Cohort profile: The Health and Retirement Study (HRS). *International Journal of Epidemiology*, 43, 576–585. [PubMed: 24671021]
- Stein PS, Desrosiers M, Donegan SJ, Yepes JK, & Kryscio RJ (2010). Tooth loss, dementia and neuropathology in the Nun Study. *The Journal of the American Dental Association*, 138, 1314–1322.
- Stein PS, Kryscio RJ, Desrosiers M, Donegan SJ, & Gibbs MB (2010). Tooth loss, apolipoprotein E, and decline in delayed word recall. *Journal of Dental Research*, 89, 473–477. [PubMed: 20139337]
- Syrjälä AM, Ylöstalo P, Hartikainen S, Sulkava R, & Knuuttila M (2010). Number of teeth and selected cardiovascular risk factors among elderly people. *Gerontology*, 27, 189–192.
- Taylor GW, & Borgnakke WS (2008). Periodontal disease: Associations with diabetes, glycemic control and complications. *Oral Diseases*, 14, 191–203. [PubMed: 18336370]
- Tonetti MS, & Van Dyke TE (2013). Periodontitis and atherosclerotic cardiovascular disease: Consensus report of the Joint EFP/AAP Workshop on Periodontitis and Systemic Diseases. *Journal of Clinical Periodontology*, 84(4 Suppl), S24–S29.
- Torres LH, Tellez M, Hilgert JB, Hugo FN, de Sousa MD, & Ismail A (2015). Frailty, frailty components, and oral health: A systematic review. *Journal of the American Geriatrics Society*, 63, 2555–2562. [PubMed: 26563844]

- Tsakos G, Watt RG, Rouxel PL, de Oliveira C, & Demakakos P (2014). Tooth loss associated with physical and cognitive decline in older adults. *Journal of the American Geriatrics Society*, 63, 91–99. [PubMed: 25523131]
- Wu B, Fillenbaum GG, Plassman BL, & Guo L (2016). Association between oral health and cognitive status: A systematic review. *Journal of the American Geriatrics Society*, 64, 739–751. [PubMed: 27037761]
- Yu YH, Lai YL, Cheung WS, & Kuo HK (2011). Oral health status and self-reported functional dependence in community-dwelling older adults. *Journal of the American Geriatrics Society*, 59, 519–523. [PubMed: 21391942]
- Zeger SL, Liang KY, & Albert PS (1988). Models for longitudinal data: A generalized estimating equation approach. *Biometrics*, 44, 1049–1060. [PubMed: 3233245]
- Zhang J, & Yu KF (1998). What's the relative risk? A method of correcting the odds ratio in cohort studies of common outcomes. *Journal of the American Medical Association*, 80, 1690–1691.
- Zou G (2004). A modified Poisson regression approach to prospective studies with binary data. *American Journal of Epidemiology*, 159, 702–706. [PubMed: 15033648]

Table 1.

Descriptive Statistics for the Overall Sample and Subsamples by Decline in ADLs/IADLs Among Older Adults in Four Waves of Data (2008–2014) From the Health and Retirement Study.

	Total N = 1,243	Decline in ADLs Yes 316 (25.4%)	Decline in IADLs Yes 316 (25.4%)
Wave			
2010	1,218	152 (12.5%)	155 (12.7%)
2012	1,109	125 (11.3%)	123 (11.1%)
2014	993	116 (11.7%)	97 (9.8%)
Age (%)			
(M = 69)			
(SD = 10)			
50–64	426 (34.3)	72 (16.9)	66 (15.5)
65–74	456 (36.7)	98 (21.5)	95 (20.8)
75–84	287 (23.1)	101 (35.2)	104 (36.2)
85+	74 (6.0)	45 (60.8)	44 (59.5)
Gender (%)			
Female	743 (59.8)	201 (27.1)	190 (25.6)
Male	500 (40.2)	115 (23.0)	119 (23.8)
Education (%)			
College+	224 (18.0)	49 (17.5)	56 (20.0)
College	444 (35.7)	66 (22.4)	61 (20.7)
HS/GED	295 (23.7)	110 (24.8)	113 (25.5)
<HS	280 (22.5)	91 (40.6)	79 (35.3)
Married/partnered (%)			
No	825 (66.4)	141 (33.7)	144 (34.4)
Yes	418 (33.6)	175 (21.2)	165 (20.0)
Race/ethnicity (%)			
White	977 (78.6)	235 (24.1)	235 (24.1)
Hispanic	120 (9.7)	39 (32.5)	33 (27.5)
Black	146 (11.7)	42 (28.8)	41 (28.1)
Household income (%)			
(M = 68,000)			
(SD = 98,000)			
0–25,000	365 (29.4)	149 (40.8)	137 (37.5)
25,000–50,000	330 (26.5)	78 (23.6)	90 (27.3)
50,000–75,000	226 (18.2)	41 (18.1)	42 (18.6)
75,000–150,000	206 (16.6)	33 (16.0)	32 (15.5)
150,000+	116 (9.3)	15 (12.9)	8 (6.9)
Comorbidities			
M (SD)	2.1 (1.5)	2.8 (1.6)	2.7 (1.5)
Median (IQR)	2 (1–3)	3 (2–4)	3 (2–4)

		<u>Decline in ADLs</u>	<u>Decline in IADLs</u>
	Total N = 1,243	Yes 316 (25.4%)	Yes 316 (25.4%)
Self-rated oral health (%)			
Very good	374 (30.1)	80 (21.4)	77 (20.6)
Good	516 (41.5)	107 (20.7)	123 (23.8)
Fair	255 (20.5)	79 (31.0)	69 (27.1)
Poor	98 (7.9)	50 (51.0)	40 (40.8)
Mouth condition (%)			
Never	525 (42.2)	123 (23.4)	116 (22.1)
Hardly ever	533 (42.9)	120 (22.5)	133 (25.0)
Occasionally	145 (11.7)	47 (32.4)	37 (25.5)
Very often/often	40 (3.2)	26 (65.0)	23 (57.5)
Tooth loss (%)			
Lost 2 teeth	364 (29.3)	62 (17.0)	74 (20.3)
Lost >2 teeth	686 (55.2)	178 (25.9)	165 (24.1)
Edentulous	193 (15.5)	76 (39.4)	70 (36.3)

Note. Mouth condition is a composite score measuring problems with oral health such as teeth/gums sensitivity and gums bleeding. IQR = interquartile range; ADL = activities of daily living; IADLs = instrumental activities of daily living. GED = General Educational Development; HS = high school.

Table 2.

Bivariate Results From the GEE Poisson Regression Models on Decline in ADLs/IADLs Among Older Adults in Four Waves of Data (2008–2014) From the Health and Retirement Study.

	Decline in ADLs	Decline in IADLs
	Crude RR (95% CI)	Crude RR (95% CI)
Wave (2010 ^a)		
2012	0.92 [0.75, 1.13]	0.89 [0.73, 1.08]
2014	0.99 [0.81, 1.21]	0.81 [0.65, 1.01]
Age (50–64 ^a)		
65–74	1.36 [1.01, 1.82] *	1.39 [1.02, 1.89] *
75–84	2.47 [1.86, 3.29] ***	2.59 [1.94, 3.46] ***
85+	4.84 [3.56, 6.59] ***	5.56 [4.04, 7.64] ***
Gender (female ^a)		
Male	0.88 [0.71, 1.09]	0.93 [0.75, 1.15]
Education (college+ ^a)		
College	1.31 [0.92, 1.87]	1.07 [0.76, 1.52]
HS/GED	1.42 [1.03, 1.97] *	1.27 [0.94, 1.73]
<HS	2.43 [1.76, 3.36] ***	1.97 [1.43, 2.72] ***
Married/partnered (no ^a)		
Yes	0.59 [0.48, 0.72] ***	0.55 [0.45, 0.68] ***
Race/ethnicity (White ^a)		
Hispanic	1.27 [0.94, 1.72]	1.05 [0.75, 1.47]
Black	1.37 [1.01, 1.85] *	1.13 [0.83, 1.53]
Household income in US\$ (0–25,000 ^a)		
25,000–50,000	0.56 [0.44, 0.73] ***	0.69 [0.54, 0.88] **
50,000–75,000	0.41 [0.30, 0.57] ***	0.47 [0.34, 0.66] ***
75,000–150,000	0.40 [0.28, 0.57] ***	0.40 [0.27, 0.57] ***
150,000+	0.28 [0.17, 0.46] ***	0.14 [0.07, 0.28] ***
Comorbidities	1.43 [1.35, 1.51] ***	1.34 [1.27, 1.43] ***
Self-rated oral health (very good ^a)		
Good	1.04 [0.79, 1.38]	1.18 [0.90, 1.54]
Fair	1.53 [1.14, 2.03] **	1.35 [0.99, 1.83]
Poor	2.54 [1.86, 3.46] ***	2.06 [1.47, 2.90] ***
Mouth condition (never ^a)		
Hardly ever	1.00 [0.78, 1.27]	1.14 [0.90, 1.45]
Occasionally	1.47 [1.08, 1.99] *	1.12 [0.79, 1.59]

	Decline in ADLs	Decline in IADLs
	Crude RR (95% CI)	Crude RR (95% CI)
Very often/often	3.16 [2.29, 4.36] ***	2.45 [1.75, 3.43] ***
Tooth loss (lost 2teeth ^a)		
Lost 2 teeth	1.67 [1.26, 2.20] ***	1.27 [0.98, 1.65]
Edentulous (no tooth)	2.68 [1.96, 3.67] ***	2.09 [1.55, 2.82] ***

Note. GEE = Generalized estimation equation; ADL = activities of daily living; IADL = instrumental activities of daily living; RR = relative risks; CI = confidence interval; GED = General Educational Development; HS = high school.

^aDenotes the reference group; relative risks and 95% CIs are provided.

*
 $p < .05$.

**
 $p < .01$.

 $p < .001$.

Table 3.

Multivariate Results From the GEE Poisson Models Regressing Decline in ADL/IADLs on Self-Rated Oral Health and Covariates Among Older Adults in Four Waves of Data (2008–2014) From the Health and Retirement Study.

	Decline in ADLs			Decline in IADLs		
	Model 1 RR (95% CI)	Model 2 RR (95% CI)	Model 3 RR (95% CI)	Model 1 RR (95% CI)	Model 2 RR (95% CI)	Model 3 RR (95% CI)
Wave (2010) ^a						
2012		0.97[0.79, 1.18]	0.98 [0.80, 1.20]		0.93 [0.76, 1.13]	0.94 [0.77, 1.15]
2014		1.09[0.89, 1.33]	1.12 [0.92, 1.38]		0.89 [0.71, 1.11]	0.91 [0.73, 1.14]
Age (50–64) ^a						
65–74		1.31 [0.97, 1.76]	1.12 [0.84, 1.50]		1.22 [0.90, 1.66]	1.10 [0.82, 1.49]
75–84		2.37 [1.76, 3.20]***	1.97 [1.50, 2.59]***		2.15 [1.57, 2.94]***	1.87 [1.39, 2.53]***
85+		3.84[2.73, 5.39]***	3.46 [2.49, 4.80]***		4.01 [2.76, 5.81]***	3.68 [2.58, 5.24]***
Gender (female) ^a						
Male		1.01[0.81, 1.25]	1.00 [0.81, 1.23]		1.08 [0.87, 1.35]	1.07 [0.87, 1.33]
Education (college+) ^a						
College		1.15 [0.81, 1.63]	1.09 [0.78, 1.53]		0.90 [0.64, 1.25]	0.87 [0.62, 1.22]
HS/GED		1.13 [0.81, 1.58]	1.11 [0.80, 1.53]		0.96 [0.71, 1.31]	0.95 [0.71, 1.28]
<HS		1.42 [1.01, 2.01]*	1.33 [0.96, 1.85]		1.19 [0.85, 1.67]	1.14 [0.82, 1.57]
Married/partnered (no) ^a						
Yes		1.03 [0.80, 1.33]	1.10[0.85, 1.41]		0.94 [0.73, 1.21]	0.97 [0.75, 1.25]
Race/ethnicity (White) ^a						
Hispanic		1.03 [0.75, 1.42]	1.19 [0.89, 1.59]		0.94 [0.66, 1.33]	1.03 [0.74, 1.43]
Black		1.13 [0.83, 1.53]	1.18 [0.87, 1.61]		0.96 [0.70, 1.32]	0.98 [0.72, 1.34]
Household income in US\$ (0–25,000) ^a						
25,000–50,000		0.74 [0.56, 0.97]*	0.73 [0.56, 0.96]*		0.87 [0.66, 1.14]	0.86 [0.66, 1.13]
50,000–75,000		0.61 [0.41, 0.89]*	0.65 [0.45, 0.95]*		0.67 [0.46, 0.98]*	0.71 [0.49, 1.03]
75,000–150,000		0.67 [0.44, 1.02]	0.73 [0.48, 1.09]		0.62 [0.40, 0.95]*	0.66 [0.43, 1.00]*

	Decline in ADLs			Decline in IADLs		
	Model 1	Model 2	Model 3	Model 1	Model 2	Model 3
	RR (95% CI)	RR (95% CI)	RR (95% CI)	RR (95% CI)	RR (95% CI)	RR (95% CI)
150,000+		0.52 [0.29, 0.91] [*]	0.65 [0.37, 1.16]		0.23 [0.11, 0.48] ^{***}	0.27 [0.13, 0.57] ^{***}
Comorbidities	1.39 [1.31, 1.48] ^{***}		1.33 [1.25, 1.42] ^{***}	1.32 [1.25, 1.41] ^{***}		1.24 [1.16, 1.32] ^{***}
Self-rated oral health (very good ^a)						
Good	0.98 [0.76, 1.28]	1.02 [0.77, 1.34]	0.96 [0.73, 1.25]	1.13 [0.87, 1.47]	1.13 [0.87, 1.47]	1.08 [0.84, 1.39]
Fair	1.43 [1.08, 1.89] [*]	1.29 [0.95, 1.73]	1.22 [0.91, 1.63]	1.28 [0.94, 1.73]	1.13 [0.83, 1.53]	1.09 [0.80, 1.47]
Poor	1.86 [1.35, 2.58] ^{***}	2.04 [1.48, 2.81] ^{***}	1.58 [1.13, 2.21] ^{**}	1.61 [1.14, 2.29] ^{**}	1.67 [1.16, 2.40] ^{**}	1.39 [0.95, 2.04]

Note. GEE = Generalized estimation equation; ADL = activities of daily living; IADL = instrumental activities of daily living; RR = relative risks; CI = confidence interval; GED = General Educational Development; HS = high school.

^aDenotes the reference group; relative risks and 95% CIs are provided.

^{*} $p < .05$.

^{**} $p < .01$.

^{***} $p < .001$.

Table 4.

Multivariate Results From the GEE Poisson Models Regressing Decline in ADL/IADLs on Mouth Condition and Covariates Among Older Adults in Four Waves of Data (2008–2014) From the Health and Retirement Study.

	Decline in ADLs			Decline in IADLs		
	Model 1 RR (95% CI)	Model 2 RR (95% CI)	Model 3 RR (95% CI)	Model 1 RR (95% CI)	Model 2 RR (95% CI)	Model 3 RR (95% CI)
Wave (2010) ^a						
2012		0.96 [0.79, 1.18]	0.98 [0.80, 1.20]		0.93 [0.76, 1.14]	0.94 [0.77, 1.15]
2014		1.08 [0.88, 1.32]	1.11 [0.91, 1.37]		0.89 [0.71, 1.11]	0.91 [0.73, 1.14]
Age (50–64) ^a						
65–74		1.31 [0.98, 1.75]	1.13 [0.85, 1.50]		1.23 [0.91, 1.68]	1.11 [0.82, 1.50]
75–84		2.37 [1.76, 3.18]***	1.96 [1.49, 2.57]***		2.11 [1.54, 2.90]***	1.84 [1.36, 2.49]***
85+		3.96 [2.80, 5.59]***	3.59 [2.57, 5.02]***		4.03 [2.80, 5.81]***	3.70 [2.60, 5.25]***
Gender (female) ^a						
Male		1.03 [0.84, 1.27]	1.00 [0.81, 1.23]		1.10 [0.89, 1.36]	1.08 [0.87, 1.33]
Education (college+) ^a						
College		1.13 [0.80, 1.60]	1.10 [0.78, 1.53]		0.89 [0.63, 1.24]	0.87 [0.63, 1.22]
HS/GED		1.16 [0.83, 1.61]	1.14 [0.83, 1.56]		0.97 [0.72, 1.31]	0.96 [0.72, 1.28]
<HS		1.41 [0.99, 1.99]	1.34 [0.96, 1.86]		1.19 [0.85, 1.67]	1.15 [0.83, 1.59]
Married/partnered (no) ^a						
Yes		1.07 [0.83, 1.39]	1.12 [0.86, 1.45]		0.95 [0.74, 1.23]	0.98 [0.76, 1.26]
Race/ethnicity (White) ^a						
Hispanic		1.01 [0.73, 1.40]	1.20 [0.89, 1.62]		0.92 [0.65, 1.31]	1.03 [0.74, 1.42]
Black		1.17 [0.86, 1.58]	1.23 [0.91, 1.66]		0.97 [0.71, 1.33]	0.99 [0.73, 1.35]
Household income in US\$ (0–25,000) ^a						
25,000–50,000		0.71 [0.54, 0.94]*	0.72 [0.55, 0.95]*		0.84 [0.64, 1.11]	0.85 [0.65, 1.11]
50,000–75,000		0.56 [0.39, 0.82]**	0.62 [0.43, 0.90]*		0.64 [0.44, 0.93]*	0.68 [0.47, 0.99]*
75,000–150,000		0.64 [0.42, 0.97]*	0.70 [0.47, 1.05]		0.59 [0.39, 0.89]*	0.63 [0.42, 0.95]*

	Decline in ADLs			Decline in IADLs		
	Model 1	Model 2	Model 3	Model 1	Model 2	Model 3
	RR (95% CI)	RR (95% CI)	RR (95% CI)	RR (95% CI)	RR (95% CI)	RR (95% CI)
150,000+		0.50 [0.28, 0.87] [*]	0.63 [0.36, 1.12]		0.22 [0.11, 0.46] ^{***}	0.26 [0.12, 0.55] ^{***}
Comorbidities	1.39 [1.31, 1.47] ^{***}		1.32 [1.24, 1.41] ^{***}	1.32 [1.24, 1.41] ^{***}		1.23 [1.15, 1.31] ^{***}
Mouth condition (never ^a)						
Hardly ever	0.91 [0.73, 1.15]	1.03 [0.82, 1.30]	0.92 [0.74, 1.16]	1.07 [0.85, 1.34]	1.21 [0.96, 1.51]	1.11 [0.89, 1.39]
Occasionally	1.30 [0.97, 1.75]	1.47 [1.09, 1.99] [*]	1.30 [0.97, 1.74]	1.02 [0.72, 1.44]	1.17 [0.82, 1.65]	1.08 [0.76, 1.52]
Very often/often	1.82 [1.24, 2.68] ^{**}	2.67 [1.83, 3.90] ^{***}	1.59 [1.02, 2.47] [*]	1.56 [1.10, 2.21] [*]	2.07 [1.45, 2.95] ^{***}	1.43 [0.96, 2.12]

Note. GEE = Generalized estimation equation; ADL = activities of daily living; IADL = instrumental activities of daily living; RR = relative risks; CI = confidence interval; GED = General Educational Development; HS = high school.

^aDenotes the reference group; relative risks and 95% CIs are provided.

^{*} $p < .05$.

^{**} $p < .01$.

^{***} $p < .001$.

Table 5.

Multivariate Results From the GEE Poisson Models Regressing Decline in ADL/IADLs on Tooth Loss and Covariates Among Older Adults in Four Waves of Data (2008–2014) From the Health and Retirement Study.

	Decline in ADLs			Decline in IADLs		
	Model 1 RR (95% CI)	Model 2 RR (95% CI)	Model 3 RR (95% CI)	Model 1 RR (95% CI)	Model 2 RR (95% CI)	Model 3 RR (95% CI)
Wave (2010) ^a						
2012		0.97 [0.79, 1.18]	0.99 [0.80, 1.21]		0.93 [0.76, 1.14]	0.95 [0.77, 1.16]
2014		1.09 [0.89, 1.33]	1.13 [0.92, 1.38]		0.89 [0.71, 1.11]	0.91 [0.73, 1.14]
Age (50–64) ^a						
65–74		1.19 [0.88, 1.62]	1.08 [0.81, 1.44]		1.17 [0.85, 1.60]	1.08 [0.80, 1.47]
75–84		2.06 [1.51, 2.81]***	1.82 [1.37, 2.41]***		1.98 [1.43, 2.74]***	1.79 [1.32, 2.42]***
85+		3.62 [2.55, 5.14]***	3.41 [2.46, 4.73]***		3.89 [2.68, 5.64]***	3.68 [2.60, 5.20]***
Gender (female) ^a						
Male		1.02 [0.82, 1.27]	1.00 [0.81, 1.22]		1.10 [0.89, 1.37]	1.08 [0.88, 1.34]
Education (college+) ^a						
College		1.11 [0.78, 1.59]	1.08 [0.77, 1.52]		0.91 [0.65, 1.27]	0.90 [0.64, 1.25]
HS/GED		1.11 [0.79, 1.56]	1.09 [0.79, 1.51]		0.99 [0.73, 1.33]	0.98 [0.73, 1.31]
<HS		1.38 [0.97, 1.96]	1.33 [0.95, 1.85]		1.20 [0.85, 1.69]	1.16 [0.84, 1.62]
Married/partnered (no) ^a						
Yes		1.04 [0.81, 1.35]	1.10 [0.85, 1.42]		0.94 [0.73, 1.21]	0.97 [0.75, 1.25]
Race/ethnicity (White) ^a						
Hispanic		1.17 [0.85, 1.61]	1.30 [0.97, 1.75]		0.97 [0.70, 1.36]	1.05 [0.76, 1.43]
Black		1.16 [0.86, 1.56]	1.21 [0.90, 1.63]		0.99 [0.72, 1.35]	1.00 [0.74, 1.36]
Household income (0–25,000) ^a						
25,000–50,000		0.69 [0.53, 0.91] ^v	0.70 [0.54, 0.92]**		0.83 [0.63, 1.09]	0.84 [0.64, 1.09]
50,000–75,000		0.59 [0.40, 0.87]**	0.64 [0.44, 0.93]*		0.65 [0.44, 0.95]*	0.68 [0.47, 0.99]*
75,000–150,000		0.65 [0.43, 0.98]*	0.71 [0.48, 1.06]		0.59 [0.39, 0.90]*	0.63 [0.41, 0.95]*

	Decline in ADLs			Decline in IADLs		
	Model 1	Model 2	Model 3	Model 1	Model 2	Model 3
	RR (95% CI)	RR (95% CI)	RR (95% CI)	RR (95% CI)	RR (95% CI)	RR (95% CI)
150,000+		0.50 [0.28, 0.87] [*]	0.65 [0.37, 1.15]		0.22 [0.10, 0.45] ^{***}	0.26 [0.12, 0.54] ^{***}
Comorbidities	1.39 [1.31, 1.47] ^{***}		1.35 [1.27, 1.43] ^{***}	1.31 [1.23, 1.40] ^{***}		1.24 [1.17, 1.33] ^{***}
Tooth loss (lost 2 teeth) ^a						
Lost more than two teeth	1.49 [1.14, 1.95] ^{**}	1.28 [0.96, 1.71]	1.25 [0.94, 1.66]	1.16 [0.90, 1.50]	0.93 [0.72, 1.20]	0.91 [0.71, 1.17]
Edentulous (no tooth)	1.82 [1.33, 2.51] ^{***}	1.60 [1.13, 2.26] ^{**}	1.33 [0.94, 1.87]	1.52 [1.11, 2.09] ^{**}	1.18 [0.86, 1.61]	1.03 [0.75, 1.41]

Note. GEE = Generalized estimation equation; ADL = activities of daily living; IADL = instrumental activities of daily living; RR = relative risks; CI = confidence interval; GED = General Educational Development; HS = high school.

^aDenotes the reference group; relative risks and 95% CIs are provided.

^{*}
p < .05.

^{**}
p < .01.

^{***}
p < .001.