Article

Oral Conditions, Oral Health Related Quality of Life and Cognitive Function: Preliminary Results from the Health and Retirement Study

Prajakta Joshi [1,2,*], Laura B. Kaufman [1,3], Howard Cabral [4]

[1] Department of General Dentistry, Boston University Henry M. Goldman School of Dental Medicine, Boston, MA 02118, USA

[2] Department of Anatomy and Neurobiology, Boston University School of Medicine, Boston, MA 02118, USA

[3] Section of Geriatrics, Department of Medicine, Boston Medical Center, Boston, MA 02118, USA

[4] Department of Biostatistics, Boston University School of Public Health, Boston, MA 02118, USA

* Correspondence: Prajakta Joshi, Email: psjoshi@bu.edu.

ABSTRACT

Background: Growing evidence suggests that cognitive functioning is influenced by oral health status. This study examines the association between the status or condition of the mouth as measured by self-report (OH), oral health related quality of life (OHRQoL) and dental care utilization on cognitive function.

Design: Population-based cross-sectional study.

Setting: United States Health and Retirement Study (2018).

Participants: Community-dwelling adults above 50 years of age (N = 1268; Mean age (SD) 67.14 ± 10.54 years).

Measurements: Self-reported condition of mouth and teeth, number of teeth and denture use were used to determine the OH. OHRQoL was assessed as a composite score using self-reported pain or distress due to gums or teeth, difficulty to relax, avoiding eating certain foods, or socializing due to oral health issues. Validated cognitive score cut-offs were used: (i) (≥12) representing normal cognition (ii) (6–11) "cognitive impairment, not demented" (CIND), and (iii) (<6) dementia.

Results: We found that participants with worse OHRQoL had 0.15 units lower global cognitive scores (β = −0.15, SE = 0.03, p = < 0.0001). Compared to those with dementia, participants in normal and CIND categories had greater odds of better OH (OR_{Normal} = 1.76, (95%CI: 1.09–2.84); OR_{CIND} = 2.86, (95%CI: 1.60–5.09)). Furthermore, participants in the CIND category had greater odds of using dentures compared to participants with dementia (OR_{CIND} = 2.71, (95%CI: 1.49–4.93)). We did not find any statistically significant association between tooth loss or dental utilization and dementia.

Conclusions: This study provides valuable preliminary insights into the potential association between OH and OHRQoL and cognitive function. If further validated, this method may allow dental and cognitive triage for follow-up assessments in community dwelling adults who may have limited access to care.

KEYWORDS: oral health; oral health related quality of life; cognition; dementia

ABBREVIATIONS

CIND, Cognitive Impairment, Not Demented
HRS, Health and Retirement Study
ISR, Institute for Social Research
OH, Oral status or condition of the mouth as measured by self-report
OHRQoL, Oral Health Related Quality of Life
TICS-m, modified Telephone Interview for Cognitive Status

INTRODUCTION

With life expectancy nearly doubled during the 20th century, there has been a ten-fold increase in the number of middle to older aged Americans [1,2]. An estimated 50 million older individuals have dementia, however, dementia it is not a normal part of ageing [3,4]. Recent studies associate poor oral health and periodontitis with greater cognitive decline and worse cognitive outcomes [5–13].

Dental pain and tooth loss may affect nutrition, functional statuses, self-confidence, precipitate stress and ultimately affect an individual's overall quality of life [5–7]. Previous studies have examined the relationship between cognition and oral health and oral health related quality of life (OHRQoL), however these studies predominantly do so with cognition as the predictor rather than the outcome [5,8–11]. Other studies examining poor oral health as an outcome, primarily focus on the physical aspect of oral function and have evaluated the association of cognitive function with tooth loss, edentulism and denture use [8,12,13].

The aim of the current study is to examine the association between status or condition of the mouth as measured by self-report (OH) and OHRQoL on cognitive function in a nationally representative population based sample of the Health and Retirement Study (HRS) in the United States of America (USA).

METHODS

Data and Study Sample

The present study utilized publicly available data from the USA HRS, a nationally representative longitudinal study of community dwelling adults. The HRS data is collected by the Institute for Social Research (ISR) at the University of Michigan (grant number NIA U01AG009740) and sponsored by the National Institute on Aging in USA who administer a combination of longitudinal household surveys, and conduct in-person and telephone based interviews. A detailed description of HRS has been published elsewhere [14–16].

The present study is a cross-sectional analysis of participants from the HRS 2018 Core data. The 'Dental Health and Dental Health Services module' was administered as an experimental module by the HRS to a randomly-selected sub-sample of HRS self-respondents, after the main (core) interview was completed [17]. Individuals who participated in the Dental Health and Dental Health Services module between April 2018 and June 2019 and responded to at least one question each from the sections assessing OH, OHRQoL, and Dental Utilization, were included in the study. The final study sample consisted of 1268 participants, after excluding those who were below 50 years of age or had missing cognitive scores on immediate and delayed recall, backward counting and serial seven subtraction tests.

Institutional Review Board (IRB) at the University of Michigan (UM) approved the study protocol (UM Health Sciences/Behavioral Sciences IRB Protocol: HUM00061128 Approved through 10/18/2018 Associated protocols: HUM00056464, HUM00002562, HUM00074501, HUM00079949, HUM00080925, HUM00085942, HUM00099822, HUM00103072, HUM00106904, HUM00122335, REP00000046).

Measures

Oral/dental measures

Self-reported Oral Health (OH) to assess the condition of the mouth was measured by three indicators: self-reported condition of mouth and teeth, number of teeth and use of dentures. Participants were asked to report if the condition of their mouth and teeth was "excellent", "very good", "good", "fair", or "poor". A binary variable was created grouping (i) 'excellent, very good, good' and (ii)'fair/poor'. The number of teeth lost were reported as (i) 'lost more than four teeth', (ii) lost less than four teeth/all teeth present"; Denture use was recorded as "yes" or "no".

Self- reported Oral health related quality of life (OHRQoL) constituted five questions from the "Section on Quality of Life" from the HRS dental module (2018) [21]. These questions pertain to the participant experiencing any of the following challenges/conditions due to problems with their teeth, mouth, or dentures. These included (i) avoidance of food,

(ii) going out, (iii) difficulty to relax, (iv) being nervous or self-consciousness and (iv) experiencing pain or distress due to the condition of their teeth, mouth, or dentures. Data was collected as an ordinal variable scored 1–5 (never, hardly ever, occasionally, fairly often, very often) across five items related to avoidance of food, going out, difficulty to relax, nervous or self-consciousness or pain and distress due to the condition of their teeth, mouth, or dentures. A summary (composite) score was calculated by adding the item response to the five OHRQoL questions.

Two self-reported questions from the "Section on Dental Utilization" of the HRS dental module (2018) were evaluated. These included the questions "wanted to see a dentist but didn't see the dentist" and dental insurance coverage; the responses were recorded as "Yes and No" responses.

Cognitive assessment

Cognitive assessment was conducted using the modified Telephone Interview for Cognitive Status (TICS-m) [18] The TICS-m comprises of three subscales that capture cognitive function in the domains of episodic memory, attention, and working memory: (i) immediate and delayed recall of 10 words from a word list randomly assigned for each participant (0–20 points), (ii) backward counting (0–2 points), and (iii) serial seven subtraction (0–5 points) [19]. The sum of scores from these subscales was calculated and is referred to as the 'global cognitive score'. The global cognitive score ranges from 0 to 27, with higher scores indicating better overall cognitive function [20].

Next, using the global cognitive function score three validated cognitive score categories were created: (i) (≥12) representing normal cognitive functioning (ii) (6–11) "cognitive impairment, not demented" (CIND), and (iii) (<6) dementia. These cut-points have been previously validated in the Aging, Demographics, and Memory Study, a national population-based study of dementia whose participants are a sub-population of the HRS [20].

Statistical Analysis

Descriptive statistical tests were used to compare the participant characteristics across cognitive score categories. Multivariable linear regression models were used to investigate associations between global cognitive scores (dependent variable), and OHRQoL score (independent variable). Lastly, a series of multinomial logistic regression were employed to evaluate the association of cognitive outcomes (cognitive score <6 as reference category) with OH, and Dental Utilization.

We considered potential co-variates including age, sex, education and current smoking, ever alcohol use and current diabetes mellitus based on previous literature [22–30]. We evaluated these variables using a stepwise forward selection process using the 'GLMSELECT' function in SAS software and appropriately adjusted our statistical models for the same. All analysis were conducted using a 0.05 level of significance as the reference.

Analyses were performed using SAS version 9.4 (SAS Institute Inc. Cary, NC, USA).

RESULTS

The descriptive characteristics of the study participants (N = 1268) by cognitive score categories (Normal, CIND and dementia) are shown in Table 1. In general, the individuals in the dementia category were older, consumed alcohol, were Caucasian and fewer participants in this category had attained higher education. A greater percentage of individuals with dementia had fair/poor self-reported OH. A greater percentage of individuals with CIND wore dentures. With respect to the individual OHRQoL items, a greater percentage of participants with dementia avoided eating certain foods, had difficulty in relaxing and were nervous or self-conscious due to the conditions of their mouth, teeth or gums.

Table 1. Characteristics of study sample by Cognitive Score Categories.

	<6 [Dementia] (N = 84)	6–11 [CIND] (N = 484)	≥12 [Normal] (N = 700)	*P*-value
Age (years, mean±SD) [Γ,*]	71.57 + 12.63	68.08 + 10.66	65.96 + 9.98	0.0001
Sex (Female N %)[†]	45 (53.57)	272 (56.20)	416 (59.43)	0.39
Education (High school or more,N%)[†,*]	16 (19.05)	145 (29.96)	315 (45.00)	<0.0001
Race (White/Caucasian, N %)[†,*]	43 (51.19)	296 (61.16)	503 (71.86)	0.02
Alcohol (Ever drink, N%)[†,*]	34 (40.48)	260 (53.72)	426 (60.86)	0.02
Diabetes (Yes, N%)[†]	24 (28.57)	114 (23.55)	160 (22.86)	0.42
Status or condition of the mouth as measured by self-report (OH) [†]				
Condition of mouth and teeth (Good/fair) [†,*]	36 (42.86)	174 (35.95)	201 (28.71)	0.003
Lost ≥ 4 teeth [†,*]	20 (30.90)	124 (34.02)	140 (21.71)	0.003
Denture use (Yes)[†,*]	20 (33.90)	69 (40.00)	54 (38.13)	0.69
Oral health related quality of life (OHRQoL) [†]				
Avoid eating certain foods? (Yes)[†,*]	34 (40.48)	120 (24.84)	144 (20.60)	0.0002
Avoid going out? (Yes) [†]	13 (15.66)	29 (6.02)	34 (4.89)	0.67
Difficult to relax? (Yes) [†,*]	22 (26.19)	71 (14.73)	82 (11.73)	0.01
Nervous or self-conscious because of problems with your teeth (Yes)[†,*]	20(23.81)	96 (20.92)	99 (14.16)	0.008
Pain or distress due to your teeth or gums (Yes) [†]	9 (10.71)	56 (11.59)	93 (13.30)	0.60
Dental Utilization [†]				
If wanted dental care but didn't go (Yes) [†]	16 (33.90)	47 (30.46)	30 (28.43)	0.55
Dental insurance (Yes) [†]	4 (30.77)	28 (59.57)	42 (65.63)	0.06

Γ Mean and standard deviation and analysis of variance test (ANOVA).

† - Counts and percentages and chi-square test * *p* < 0.05 level of significance. ⱡ Self-reported measures.

Table 2. shows the results of the multivariate linear regression model testing the association between self-reported OHRQoL and Global

cognitive scores. The model was adjusted for sex, age, race, low education attainment (less than high school completed), current smoking, ever alcohol use and current diabetes mellitus. The adjusted model shows that individuals with worse self-reported OHRQoL had 0.15 units lower global cognitive scores (β = −0.15, SE = 0.03, $p \leq 0.0001$).

Table 2. Adjusted Multivariate linear regression model and 95% confidence intervals of the association between self-reported OHRQoL and global cognitive scores.

	β estimate	SE	P-value	95% CI	
				Lower	Upper
OHRQoL model [†,*]	−0.15	0.03	<0.0001	−0.21	−0.09

† Self-reported measures. * <0.05 level of significance. SE = standard error.

Models were adjusted for sex, age, race (white, black, other), low education attainment (less than high school completed), current smoking, ever alcohol use and current diabetes mellitus.

Lastly, in order to provide results in the form of commonly employed clinically relevant cognitive status groupings, we used a series of multinomial logistic regression analyses to evaluate the association between cognitive outcomes defined above (normal cognition, CIND and dementia) with OH and Dental Utilization. Global cognitive score <6 representing Dementia was taken as the reference group. Compared to participants with dementia, those in both Normal and CIND groups had greater odds of having better self-reported OH conditions (OR_{Normal} = 1.76, (95%CI: 1.09–2.84); OR_{CIND} = 2.86, (95%CI: 1.60–5.09)). Neither participants in the Normal nor CIND were associated with having ≥ 4 teeth, however, participants in the CIND group had greater odds of using dentures (OR_{CIND} = 2.71, (95%CI: 1.49–4.93)) compared to those with dementia. With regard to dental utilization, individuals with normal cognition had slightly lower odds of wanting to go to the dentist but not going for a dental visit, when compared to those in the dementia category (OR_{Normal} = 0.98, (95% CI: 0.94–0.999)), however, these findings did not reach statistical significance. No association was found between cognitive score categories and dental insurance coverage.

DISCUSSION

The present study assessed the association between self-reported OH, OHRQoL, dental utilization and cognitive function in a nationally representative sample of adults over the age of 50 years. This study adds to the oral health and cognitive function literature by investigating the role of OH and OHRQoL as risk factors of cognitive function.

A number of studies have focused on the 'oral function' aspect of oral health and have evaluated the association between cognitive function with surrogates of oral conditions by measuring tooth loss, edentulism and denture use [5,8,12,13]. Ge et al. reported that worse oral health resulted in faster decline of cognitive functioning in racially diverse populations [17]. Consistent with previous literature our study showed that

participants in the Normal and CIND categories had better self-reported OH compared to the participants in the dementia category. A meta-analysis focusing on tooth loss, diminished cognitive function and risk of dementia showed that that individuals with fewer teeth were at a 20% higher risk for developing cognitive decline [8]. Paradoxically, the present study did not find any association between tooth loss and dementia (Table 3). Though further validation is needed, a potential explanation of these results could be that individuals with dementia may indeed have worse conditions of mouth and teeth, which is consistent with our findings, but they may not be able to get the periodontally compromised or decayed teeth extracted due to lack of patient cooperation or due to extensive inflammation and infection.

Table 3. Multinomial logistic regression between self-reported OH, Dental Utilization and cognitive categories.

	β estimate	SE	*P*-value	OR (95% CI)		
				OR	Lower	Upper
Status or condition of the mouth as measured by self-report (OH) [†]						
Condition of mouth and teeth (Good/fair)						
Normal *	0.28	0.12	<0.0001	1.76	1.09	2.84
CIND *	1.05	0.29	0.0004	2.86	1.60	5.09
Lost ≥ 4 teeth						
Normal	0.19	0.14	0.20	1.46	0.81	2.62
CIND	0.04	0.15	0.09	1.09	0.61	1.97
Denture use						
Normal	0.44	0.31	0.15	1.55	0.85	2.86
CIND*	0.99	0.30	0.0011	2.71	1.49	4.93
Dental Utilization [†]						
If wanted dentist but didn't go						
Normal	−2.03	6.44	0.056	0.98	0.94	0.999
CIND	−3.06	8.15	0.94	1.28	0.81	2.03
No dental insurance						
Normal	−0.59	0.34	0.08	0.30	0.07	1.18
CIND	−0.53	0.35	0.13	0.34	0.08	1.41

SE = standard error. OR= Odds ratio. ꝷ Self-reported measures. * <0.05 level of significance.

Cognitive score range <6 representing Dementia was used as the reference.

Models were adjusted for sex, age, race (white, black, other), low education attainment (less than high school completed), smoking, ever alcohol use and current diabetes mellitus.

Two investigators have utilized HRS data from previous waves (2008) to study the associations between edentulism, and cognitive functioning [7,12]; The study by Han et al. found that edentulism and dental care service utilization were independently associated with cognitive decline [12]. Similarly, we found that cognitively normal participants were not associated with denture use while those with CIND were more likely to use

dentures than participants with dementia, and these findings are consistent with previous literature [14,16]. Based on our findings, we think that distinguishing between participants with CIND and dementia is key from a clinical perspective. A potential explanation for lower denture use in participants with dementia might be that fabrication of dentures requires multiple long dental appointments and losing dentures is commonly seen in individuals with dementia. Future investigation tracking denture use followed by clinical dental examination would be required to validate these findings.

OHRQoL includes a subjective evaluation of the individual's oral health, functional status, emotional well-being, and a sense of self [31]. While most investigators focus predominantly on oral health status, the assessment of the latter components may help gain valuable insights into an individual's behavioral, emotional and psychosocial functioning that may be impacted by dementia [32]. Fewer studies have evaluated the association between OHRQoL and cognition. A study by Wong et al. reviewed twenty-five surveys (or study series) from 19 countries and found that among institutionalized older adults, those with worse cognition (mild or above cognitive impairment)had poor OH and OHRQoL [14]. Another study by Jing et al. found a positive reciprocal association between cognition and OH and OHRQoL [33]. Consistent with these studies, we found that individuals with worse self-reported composite OHRQoL score had 0.15 units lower global cognitive scores.

The strengths of this study include representation of community dwelling middle to older aged adults, utilization of items from validated cognitive and OHRQoL measures [34–36]. Furthermore, previous studies show that the TICS-m may relate to more common cognitive scales such as the Montreal Cognitive Assessment (MoCA) or the Mini-Mental State Examination (MMSE) [37,38]. Although these findings are valuable, our study has some limitations. Some of the limitations of our study include small sample size, the use of dental parameters collected from a sub-sample of the HRS participants, and self-report of dental conditions. Although HRS randomly selected participants who would be administered the dental module, it is possible that severely demented individuals may not respond to paper-based surveys, thus underestimating the effect of the intervention. Additionally, clinical oral examination and self-reported OH may not always be concordant, especially in individuals with CIND or dementia and thus, further investigation verifying this concordance is needed. Furthermore, although previously validated, relying on population-based cut-offs to create cognitive score categories (normal, CIND, dementia) may introduce systematic errors. From a life-course perspective, a number of factors such as low education, cardiovascular disease, smoking, diabetes may influence the potential association between poor oral conditions and cognitive functioning. To some extent, we have accounted for the potential confounding factors in the analysis, however, effects of residual confounding may remain. Furthermore, due

to the cross-sectional nature of our study the exposure and outcome have been simultaneously assessed, and thus further study would be needed to assess the potential temporal relationship between OH, OHRQoL and cognitive function.

Despite these limitations, our findings provide valuable information associating poor OH and lower OHRQoL with worse cognitive function. If validated, through longitudinal studies and clinical dental examination, these methods of employing self-reported OH and OHRQoL as well as the use of modified Telephone Interview for Cognitive Status might be practical screening modalities for middle to older aged individuals who may be home-bound, medically compromised or may have limited access to care.

AUTHOR CONTRIBUTIONS

Prajakta Joshi designed the study and analyzed the data. Howard Cabral helped design the statistical analysis section, interpreting and writing the results, and discussion sections. Prajakta Joshi and Laura B. Kaufman wrote the paper with input from all authors.

CONFLICTS OF INTEREST

The authors declare that they have no conflicts of interest.

FUNDING

REFERENCES

1. NIA. The National Institute on Aging: Strategic Directions for Research, 2020-2025. Available from: https://www.nia.nih.gov/living-long-well-21st-century-strategic-directions-research-aging/introduction. Accessed 2021 December 22.
2. US Census Bureau. 2020 Census Will Help Policymakers Prepare for the Incoming Wave of Aging Boomers. Available from: https://www.census.gov/library/stories/2019/12/by-2030-all-baby-boomers-will-be-age-65-or-older.html. Accessed 2021 Dec 27.
3. Wu B, Plassman BL, Liang J, Wei L. Cognitive Function and Dental Care Utilization Among Community-Dwelling Older Adults. Am J Public Health. 2007 Dec 1;97(12):2216-21.
4. World Health Organization. Dementia. Available from: http://www.who.int/news-room/fact-sheets/detail/dementia. Accessed 2021 Dec 22.

5. Oral Health and Cognitive Function in Older Adults: A Systematic Review. Gerontology. 2019;65:6.

6. El-Yousfi S, Jones K, White S, Marshman Z. A rapid review of barriers to oral healthcare for vulnerable people. Br Dent J. 2019 Jul;227(2):143-51.

7. Weintraub JA, Orleans B, Fontana M, Phillips C, Jones JA. Factors Associated With Becoming Edentulous in the US Health and Retirement Study. J Am Geriatr Soc. 2019 Nov;67(11):2318-24.

8. Cerutti-Kopplin D, Feine J, Padilha DM, de Souza RF, Ahmadi M, Rompré P, et al. Tooth Loss Increases the Risk of Diminished Cognitive Function: A Systematic Review and Meta-analysis. JDR Clin Transl Res. 2016 Apr 1;1(1):10-9.

9. Zuluaga DJM, Montoya JAG, Contreras CI, Herrera RR. Association between oral health, cognitive impairment and oral health-related quality of life. Gerodontology. 2012 Jun;29(2):e667-73.

10. Lee KH, Wu B, Plassman BL. Cognitive function and oral health-related quality of life in older adults. J Am Geriatr Soc. 2013 Sep;61(9):1602-7.

11. Han SH, Wu B, Burr JA. Edentulism and Trajectories of Cognitive Functioning Among Older Adults: The Role of Dental Care Service Utilization. J Aging Health. 2019 May 26;32(7-8):744-52.

12. Ge S, Xu H, Zhang W, Wu B. Does Oral Health Predict Cognitive Decline Among Older Adults? The Health and Retirement Study. Available from: https://sigma.nursingrepository.org/handle/10755/622434. Accessed 2021 Dec 22.

13. Sischo L, Broder HL. Oral Health-related Quality of Life. J Dent Res. 2011 Nov;90(11):1264-70.

14. Sonnega A, Faul JD, Ofstedal MB, Langa KM, Phillips JW, Weir DR. Cohort Profile: the Health and Retirement Study (HRS). Int J Epidemiol. 2014 Apr;43(2):576-85.

15. Health and Retirement Study. Welcome to the Health and Retirement Study. Available from: http://hrsonline.isr.umich.edu.ezproxy.bu.edu/. Accessed 2021 Dec 22.

16. National Institute on Aging; National Institutes of Health; US Department of Health and Human Services. Growing older in America: The health & retirement study. Available from: https://www.nia.nih.gov/sites/default/files/2017-06/health_and_retirement_study_0.pdf. Accessed 2021 Dec 22.

17. Health and Retirement Study. New Experimental Modules for HRS 2018 Invited | Health and Retirement Study. Available from: https://hrs.isr.umich.edu/news/general-announcements/new-experimental-modules-hrs-2018-invited. Accessed 2021 Dec 22.

18. Fong TG, Fearing MA, Jones RN, Shi P, Marcantonio ER, Rudolph JL, et al. The Telephone Interview for Cognitive Status: Creating a crosswalk with the Mini-Mental State Exam. Alzheimers Dement J Alzheimers Assoc. 2009 Nov;5(6):492-7.

19. Sandberg MA. Serial Subtractions. In: Kreutzer JS, DeLuca J, Caplan B, editors. Encyclopedia of Clinical Neuropsychology. New York (NY, US): Springer; 2011. p. 2267-8.

20. Crimmins EM, Kim JK, Langa KM, Weir DR. Assessment of cognition using surveys and neuropsychological assessment: the Health and Retirement Study and the Aging, Demographics, and Memory Study. J Gerontol B Psychol Sci Soc Sci. 2011 Jul;66(Suppl 1):i162-71.

21. Health and Retirement Study. HRS 2018—Module 3: Dental Health and Dental Health Services, Health And Retirement Study. Available from https://hrs.isr.umich.edu/documentation/modules#2018. Accessed 2021 Dec 27.

22. Liang J, Quiñones AR, Bennett JM, Ye W, Xu X, Shaw BA, et al. Evolving Self-Rated Health in Middle and Old Age: How Does It Differ Across Black, Hispanic, and White Americans? J Aging Health. 2010 Feb;22(1):3-26.

23. Azad NA, Al Bugami M, Loy-English I. Gender differences in dementia risk factors. Gend Med. 2007;4(2):120-9.

24. Elias MF, Elias PK, D'agostino RB, Silbershatz H, Wolf PA. Role of age, education, and gender on cognitive performance in the Framingham Heart Study: community-based norms. Exp Aging Res. 1997;23(3):201-35.

25. Naghibi Sistani MM, Yazdani R, Virtanen J, Pakdaman A, Murtomaa H. Determinants of Oral Health: Does Oral Health Literacy Matter? ISRN Dent. 2013;2013:249591.

26. Leite FRM, Nascimento GG, Scheutz F, López R. Effect of Smoking on Periodontitis: A Systematic Review and Meta-regression. Am J Prev Med. 2018 Jun 1;54(6):831-41.

27. Batty GD, Shipley MJ, Kvaavik E, Russ T, Hamer M, Stamatakis E, et al. Biomarker Assessment of Tobacco Smoking Exposure and Risk of Dementia Death: Pooling of Individual Participant Data From 14 Cohort Studies. J Epidemiol Community Health. 2018 Jun;72(6):513-15.

28. Xu W, Wang H, Wan Y, Tan C, Li J, Tan L, et al. Alcohol Consumption and Dementia Risk: A Dose-Response Meta-Analysis of Prospective Studies. Eur J Epidemiol. 2017 Jan;32(1):31-42.

29. Nascimento GG, Leite FRM, Vestergaard P, Scheutz F, López R. Does diabetes increase the risk of periodontitis? A systematic review and meta-regression analysis of longitudinal prospective studies. Acta Diabetol. 2018 Jul 1;55(7):653-67.

30. Akomolafe A, Beiser A, Meigs JB, Au R, Green RC, Farrer LA, et al. Diabetes Mellitus and Risk of Developing Alzheimer Disease: Results From the Framingham Study. Arch Neurol. 2006 Nov 1;63(11):1551-5.

31. McKeith I, Cummings J. Behavioural changes and psychological symptoms in dementia disorders. Lancet Neurol. 2005 Nov 1;4(11):735-42.

32. Kang J, Wu B, Bunce D, Ide M, Aggarwal VR, Pavitt S, et al. Bidirectional relations between cognitive function and oral health in ageing persons: a longitudinal cohort study. Age Ageing. 2020;49(5):793-9.

33. Wong FMF, Ng YTY, Leung WK. Oral Health and Its Associated Factors Among Older Institutionalized Residents-A Systematic Review. Int J Environ Res Public Health. 2019 26;16(21):4132.

34. Atchison KA, Dolan TA. Development of the geriatric oral health assessment index. J Dent Educ. 1990 Nov;54(11):680-7.

35. Brandt J, Spencer M, Folstein M. The telephone interview for cognitive status. Neuropsychiatry Neuropsychol Behav Neurol. 1988 Jun;1(2):111-7.

36. Calabrese JM, Friedman PK, Rose LM, Jones JA. Using the GOHAI to assess oral health status of frail homebound elders: reliability, sensitivity, and specificity. Spec Care Dentistry. 1999 Sep;19(5):214-9.

37. Fong TG, Fearing MA, Jones RN, Shi P, Marcantonio ER, Rudolph JL, et al. Telephone interview for cognitive status: Creating a crosswalk with the Mini-Mental State Examination. Alzheimers Dement. 2009 Nov 1;5(6):492-7.

38. Pendlebury ST, Welch SJ, Cuthbertson FC, Mariz J, Mehta Z, Rothwell PM. Telephone assessment of cognition after TIA and stroke: TICSm and telephone MoCA vs face-to-face MoCA and neuropsychological battery. Stroke. 2013 Jan;44(1):227.