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The oral health status of residents with different cognitive and dental related functions in three North Carolina assisted-living facilities

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Abstract

Introduction: The aim of the study was to describe the oral health status of assisted-living residents with different cognition and dental related functions (DRFs).

Methods: The present study was a secondary analysis of data collected for a cross-sectional study of residents in three assisted-living facilities in North Carolina. The participants were aged 50 years or older, had normal to severely-impaired cognition, and spoke English. Upon obtaining informed consent, an oral assessment was completed by a trained geriatric dentist. A research team member who was blind to the oral examination outcomes then used the Minimum Data Set Cognition Scale (MDS-COGS) to assess participants’ cognition and the Dental Activities Test (DAT) to evaluate oral self-care and other DRFs. Descriptive statistics were used to describe the demographic, cognitive, functional and oral health status of the study participants. The impacts of cognitive and functional status on oral health measures were examined using simple linear regression models, negative binomial and zero-inflated negative binomial models.

Results: A total of 91 residents from three assisted-living facilities participated in the study. Oral hygiene and gingival health were significantly associated with cognition ($p = 0.056$ and $p = 0.017$, respectively) and DRFs ($p = 0.013$ and $p = 0.008$, respectively). Residents with poor cognitive and dental-related function also presented with poor oral hygiene and gingival health.

Conclusion: The study results suggest that oral hygiene and gingival health were significantly associated with cognition and DRFs.

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Keywords

Cognitive impairment; Dental related functions; Oral hygiene; Dental caries

INTRODUCTION

Dementia is a syndrome caused by a number of progressive illnesses that affect a person's cognition, social behaviors and daily functions¹. It is highly prevalent in older adults and thus, poses a significant burden on the society². It has been estimated that 5-7% of 60-year-old individuals and 20% of 85-year-old individuals are affected by dementia¹. Dementia is associated with high levels of disability, which interferes with one's social and physical functioning^{3,4}. More specifically, it affects an individual's ability to recall, learn, understand, perceive, reason and execute routine day-to-day tasks⁵. Impaired daily function⁶ and language impairment are common in persons with dementia. Other symptoms such as apathy (lack of interest)⁷, anosognosia (inability to understand and perceive one's illness)⁸, apraxia⁹ (inability to perform complete or partial planned muscular movements) are also frequently seen in these individuals. Cognitive decline is progressive, often starting at mild, growing to moderate and then severely declining¹⁰, and the decline can be more rapid in the terminal phase¹¹. It, therefore, has significant consequences on the lives of the affected individuals.

Evidence suggests that cognition, dental related function (i.e., ability to perform oral self-care, manage dental-related medications, comprehend and follow homecare instructions and perceive and respond to an oral health condition, DRF) and oral health are intercorrelated¹². Cognitive function (e.g., memory, attention, language function and executive function) underlies oral health related activities (e.g., brushing teeth and the use of fluoride)^{13,14}. When cognition is impaired, it can lead to limitations in generic cognitive tasks and compromises an individual's ability to perform oral self-care¹⁵. Impaired prospective memory¹³ can change the oral hygiene routine (e.g., time and frequency)¹⁶ and be detrimental to oral hygiene²¹. Global cognitive impairment (e.g., attention deficit and impaired visuospatial function) and executive dysfunction can affect an individual's ability to plan, sequence and carry out oral hygiene activities and compromise the quality of oral self-care^{13,17}. As a result of cognitive and functional impairment, oral health may decline in persons with cognitive impairment (PWCI). When compared to persons without cognitive impairment, PWCI are more likely to have poorer oral hygiene^{18,19}, more severe gingival inflammation¹⁸, a greater amount of alveolar bone loss¹⁹, more dental caries^{12,20,21}, fewer remaining teeth^{19,21-23}, more denture-related issues²⁴ and a greater degree of dry mouth²⁰. While oral health is poor in PWCI, neuropsychiatric symptoms, such as anosognosia, can alter the perceptions of these individuals on oral health. This problem, together with language impairment and apathy, can negatively affect their help-seeking behavior, treatment decisions, alter their ability and willingness to follow homecare instructions²⁵⁻²⁸ and accelerate oral health decline in PWCI. Compromised oral health not only increases pain and suffering of the affected individuals, but also leads to other serious consequences, such as local abscesses, bacteremia²⁹, brain abscesses³⁰, endocarditis²⁹, and aspiration pneumonia³¹.

Although numerous studies^{19, 21–23} have explored the oral health status of PWCI, there is a serious dearth of literature on the oral health implications of the various cognitive and DRF levels. This paucity limits our ability to develop an individualized, functionally-tailored oral health intervention for maintaining and/or improving oral health for PWCI. Given that, we conducted a secondary analysis of an existing dataset to describe the oral health status of residents with various capacities for cognition and levels of dental related function in three North Carolina assisted-living programs.

MATERIALS AND METHODS

The present study is a secondary analysis of data collected for a cross-sectional study of residents living in three assisted living residences in North Carolina, USA. The goal of the parent study was to develop and validate the Dental Activity Test (DAT), a nine-item scale for measuring DRFs in PWCI. The ethical approval was obtained from the Institutional Review Boards of the University of Iowa and the University of North Carolina before the study. The design, sampling method, and data collection protocol of the parent study have been reported in detail elsewhere³², and briefly described below.

Study participants.

A convenient sample was recruited for the original study from three assisted living facilities in North Carolina. Ninety-one residents meeting the following inclusion criteria were invited to participate in the parent study: 50 years or older; having normal to severely-impaired cognitive function; English speaking; no severe disability (e.g., hemiplegia), blindness or deafness. Those who required antibiotic prophylaxis before dental treatment or an immediate dental referral were excluded. The sample size was estimated following the measurement development literature³³. Given that multiple items were developed to define one factor, a relatively small sample sizes can be used to achieve good factor recovery³⁴. For this reason, a 10:1 sample to variable ratio was used for the parent study.

Data collection.

After obtaining the written informed consent from the participants or their family members, an oral assessment was completed by a geriatric dentist trained for the study. Then, a research staff member, who was blind to the oral examination outcomes, visited the study participant and their caregivers within one week of their oral examination and completed the participants' cognitive and dental-related functional assessments. All the research staff were trained and calibrated before data collection began.

Oral health assessments.

The participants' oral hygiene status was evaluated using validated oral hygiene measurement tools, including the Debris Index (DI) of the Oral Hygiene Index³⁵, the Gingival Index (GI)³⁶ and the Denture Plaque Index (DPI)³⁷. In addition to this, the number of remaining teeth, the number of teeth with active caries (i.e., cavitated carious lesions), and the number of retained roots were also recorded.

Cognitive assessment.

Cognitive function was evaluated using the Minimum Data Set Cognition Scale (MDS-COGS)³⁸. This scale uses the information available in the Minimum Data Set to assess the cognitive status of assisted living residents and has been widely used in long-term care settings³⁹. MDS-COGS scores range from 0-10, and using these scores, cognition WAS classified as follows: Score 0-1 represents cognitively intact – mild cognitive impairment; 2-4 represents mild-moderate impairment; 5-8 represents moderate-severe impairment and 9-10 represents severe-very severe impairment³⁸.

Dental-related function (DRF) assessment. DRF was evaluated using the Dental Activities Test (DAT), which is a reliable and valid tool for measuring the DRF in PWCI³². The DAT was specifically designed to measure four DRF domains that are essential for maintaining the oral health of PWCI. It consists of nine oral health-related activities, including following the instructions of a medication schedule, rinsing the mouth, opening and closing the mouth, moving the tongue, brushing teeth, putting toothpaste on a toothbrush, locating the lower front teeth with a finger, describing the status of the upper right front tooth, and making a decision about a hypothetical acute oral infection³². During the assessment, participants were asked to complete each of these tasks as directed. The examiner assessed and scored their performance on individual items using a binary scale, 0 or 1. The total DRF scores were computed by summing the scores for all 9 items, and they reflect an individual's ability to perform oral self-care and other oral health related activities. Based on these scores, the participants were classified into 4 DRF groups: Independent (DRF = 9), Needs Supervision (DRF= 6-8), Needs Assistance (DRF scores = 3-5) and Full Care (DRF scores = 0-2) as specified in the DAT manual.

Statistical Analysis.

Data were analyzed using the STATA software version 13.0 (StataCorp, College Station, TX, USA) using 0.05 significance level for all analyses. Descriptive statistics were conducted to describe the demographic, cognitive, functional and oral health statuses of the study participants. For each cognitive and functional level, the oral hygiene and oral health status was then described. Three regression models were developed to assess the impacts of cognitive impairment on oral health outcomes. First, linear regression models were adopted for plaque and gingival indices adjusting for age at enrollment, gender, race, years living in the facility and facility type. Then, a negative binomial regression model was developed with the number of remaining teeth as the dependent variable. In addition to the aforementioned covariates, dental insurance was also adjusted for in this model. Finally, the zero-inflated negative binomial (ZINB) regression was used to model the number of teeth with active caries given that a considerable proportion of the participants presented with no caries. Age at enrollment, gender, race, years living in the facility, facility type, dental insurance and number of remaining teeth were also added into the model to adjust for their impacts on the outcome. Residual plots were used to assess the fit of the linear regression models while the fit of the negative binomial and ZINB were assessed by comparing the observed relative frequencies and the estimated ZINB probabilities. The same approach was also used to investigate the influence of DRF on oral health outcomes after adjusting for the aforementioned covariates.

RESULTS

Characteristics of the study participants

A total of 91 residents from the aforementioned three assisted living facilities participated in the study. The mean age of the study participants was 84.3 years. The majority of them were females (80.2%); 68.1% were white and 29.7% were black, and only 17.6% were married. The mean length of stay in the facility was 2.8 years. Nearly 70% of the participants resided in a for-profit facility. Twenty-nine percent of the participants had dental insurance but only one visited a dentist in the past year. The characteristics of the study participants are presented in Table 1.

In terms of cognitive function, the mean MDS-COGS was 3.6, indicating mild to moderate impairment in cognition. Thirty-four (37.4%) of the participants had no or mild cognitive impairment, 23 (25.3%) were mild to moderately impaired, 23 (25.3%) were moderate to severely impaired, and 11 (12.1%) had a severe or very severe impairment. The mean DAT score was 5.9 (SD=3.0), suggesting mild to moderate impairment in DRF. Specifically, 15(16.7%) performed oral self-care and other oral health related activities independently, 19 (21.1%) needed supervision, 42 (45.6%) needed assistance and 15 (16.7%) were fully dependent on others for oral self-care.

Twenty-five percent of the participants were edentulous. Among the dentate participants, the mean DI and GI scores were 1.8 and 1.5 respectively, indicating poor oral hygiene and considerable gingival inflammation. Among the 68 dentate participants, the mean number of teeth present was 19.3 teeth, of which 37.1% had untreated, cavitated caries with the mean number of active caries 7.2.

Cognitive impairment and oral health

Oral health measures and their association with cognitive impairment are presented in Table 2 and 3. Bivariate analysis showed that both oral hygiene (measured by Debris Index) and gingival health (measured by Gingival Index) were positively associated with cognitive impairment. Participants with worse cognitive function had poorer oral hygiene ($p = 0.056$) and gingival health ($p = 0.017$, Table 2). After adjusting for age, sex, race, marital status, facility type and years in the facility, cognitive impairment remained positively and significantly associated with both oral hygiene and gingival health ($p=0.017$ and $p=0.004$, respectively).

The number of remaining teeth was not associated with cognitive impairment (Table 2 and 3). Participants with severe to very severe cognitive impairment tended to have more active caries than other groups (Table 2), yet this association was marginally nonsignificant after adjusting for age, sex, race, marital status, facility type, years in the facility, dental insurance and the number of remaining teeth ($p=0.055$, Table 3).

Dental-related function and oral health

Similar patterns were also observed in the associations between DRF and oral health outcomes. Oral hygiene ($p= 0.013$) and gingival health ($p= 0.008$) were significantly

associated with DRFs (Table 2). Individuals in the Full Care group had worst oral hygiene and gingival health. These associations remained significant after adjusting for the aforementioned covariates (Table 3).

Although the associations between DRF and the number of remaining teeth or the number of teeth with active caries were not significant, participants with moderate or severe DRF impairment tended to have more active dental caries than those with no or mild impairment on DRFs (Table 2).

DISCUSSION

In the present study, we explored the oral health statuses of assisted living residents with different levels of cognition and DRFs and found that as cognitive or DRF impairment progressed, oral hygiene declined. Gingival inflammation, which is a result of prolonged oral hygiene deterioration, also significantly increased in participants with poor cognition or DRF. Individuals with moderate or severe impairment in cognitive or DRFs tended to have more active dental caries than those with no or mild cognitive or DRF impairment, yet these associations did not reach statistical significance. Similarly, there was no association between cognition/DRF and the number of remaining teeth. To our knowledge, this is the first study that described oral health status in long-term care residents with different levels of impairment in cognition and DRFs.

One interesting finding of this study is that although oral hygiene significantly declined as cognitive and DRF impairment progressed, dental caries did not significantly increase during this process. This finding differs from that of previous studies, which suggests cognitive impairment was associated with dental caries^{21, 40}. Individuals with poorer cognition usually have more dental caries^{21, 40}. Several reasons may contribute to this discrepancy. First of all, cognitive impairment or DRF may not be directly associated with dental caries. Studies show that oral self-care capacity mediates the association between cognitive impairment and dental caries^{12, 41}. These evidences suggest that cognitive impairment can compromise an individual's oral self-care capacity and other DRFs, which lead to oral hygiene decline. It is poor oral hygiene that increases the risk of dental caries in PWCI. Besides impaired DRF and declined oral hygiene, several other factors such as sugar consumption^{42, 43}, xerostomia⁴⁴, inadequate caregiver support and the lack of access to care increases the caries risk while fluoride can provide protection against caries⁴⁵. These factors all contribute the development and progression of dental caries in PWCI and therefore, modify the associations between cognitive or DRF impairment and dental caries.

The oral hygiene significantly varied in participants with different functional levels suggests that an objective, structured DRF assessment should also be included in geriatric oral assessments. An assessment on oral hygiene, DRFs and caregiver support enables dental professionals to better understand and address the oral hygiene needs of PWCI. However, currently only a small proportions of dental professionals (6%) evaluate DRFs using a standardized cognitive or functional assessment instruments⁴⁶, such as Katz Index of Independence in Activities of Daily Living⁴⁷, the Lawton Instrumental Activities of Daily Living Scale⁴⁸ or the Mini-Mental State Examination⁴⁹. However, these instruments are

not specific and do not accurately reflect an individual's ability to perform mouth care and other oral health related activities. The DAT is more appropriate for this purpose. It has shown to be a valid instrument for evaluating DRFs of cognitively impaired individuals and allows dental professionals to reliably classify a patient's DRFs³².

Evidence shows that oral self-care function play a critical role in oral health deterioration in PWCI^{12, 40, 41, 50}. These findings suggest that oral self-care and other DRF should be considered during clinical treatment planning. In such way, oral health interventions can be tailored corresponding to PWCI's oral health needs, function and caregiver support to achieve desired outcomes. Based on the DAT, PWCI can be categorized into four functional groups (i.e., Independent, Needs Supervision, Needs Assistance, and Full Care)³². Dyadic, functionally tailored oral hygiene interventions can then be developed to improve oral hygiene for cognitively impaired individuals and address the caregiving needs of their caregivers. Individuals who are in the Independent group may perform oral health-related activities independently or with little help, but the quality of their performance may be compromised^{51, 52}. Therefore, oral care intervention should target PWCI and help them to maintain and improve their oral health. Quality improvement techniques may be introduced to caregivers to achieve desired oral care outcome. Similar approaches are also applicable to PWCI in the Need Supervision group. In addition, verbal, visual and sensory cues can be used to help caregivers provide necessary assistance to PWCI^{51, 53}. PWCI in the Need Assistance and Full Care groups usually rely on caregivers for oral care, and yet provision of oral care is often limited by lack of caregiver training and guidance, time pressures, low oral health literacy, the perception that mouth care is unimportant, distaste for the activity, and fear of resistant behaviors.⁵⁴ Therefore, in addition to quality improvement and curing techniques, oral care techniques and behavior management approaches should be introduced to these individuals. For PWCI with limited communication capacity, caregivers should be trained to recognize the signs and symptoms related to dental pain or infection⁵⁵ so that timely treatment can be provided to avoid prolonged suffering.

The following limitations should be kept in mind while interpreting the study findings. First, this study was conducted with residents of three assisted living care residents of North Carolina using a convenience sample. Their standard operating practices might be different than other long-term care facilities in the state, country or other parts of the world. The residents who participated in our study may differ from those who did not participate, thereby resulting in a possible volunteer bias. Thus, our study findings may not be applicable to other long-term care residents. Second, it was a secondary analysis using the data of a cross-sectional study, and the design limits us from determining the temporal relationship between cognition impairment, DRF decline, and oral health. Therefore, the causal relationships between cognitive, functional and oral health measures remain unknown. Whether and how cognitive and functional impairment leads to increased dental caries remains unclear. Third, although the study sample was adequate for the original study, it was small for the present study. Of the total 91 participants, 25.27 % were edentulous, which left 68 participants for investigating the association between cognitive impairment, DRF, and oral health outcomes. Although the well accepted "rule of thumb" of 10 to 1 subjects-to-variable ratio was followed during the multivariate analysis, the study might be underpowered. Several potential confounders such as xerostomia, caregiver support, dental

utilization pattern and diet were not adjusted in the analysis, which is also a limitation of this study.

In conclusion, our study revealed that oral hygiene and gingival health deteriorated along with the declines in cognition and DRFs. These findings suggest that DRFs should be evaluated as part of the assessment of the geriatric dental patients so that functionally tailored interventions can be developed to improve oral health for PWCI.

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Table 1.

Characteristics of study subjects (N=91)

Characteristics	Study subjects
Sociodemographic	
Age (Mean, SD, Min–Max)	84.3 ± 9.0 (54 - 102)
Female (n, %)	73 (80.2)
Race (n, %)	
White	62 (68.1)
Black	27 (29.7)
Other	2 (2.2)
Married (n, %)	
No	67 (73.6)
Yes	16 (17.6)
Unknown	8 (8.8)
Living in a for-profit facility (n, %)	62 (68.1)
Years in the facility (Mean ± SD, Min–Max)	2.8 ± 2.6 (0 - 12)
Having dental insurance (n, %)	26 (28.6)
Visited a dentist in the past year (n, %)	1 (1.1)
Cognition and Dental Related Function	
*Cognition (Mean ± SD, Min–Max)	3.6 ± 3.4 (0 - 10)
Intact-Mild (0-1)	34 (37.4)
Mild-Moderate (2-4)	23 (25.3)
Moderate-Severe (5-8)	23 (25.3)
Severe-Very severe (9-10)	11 (12.1)
*Dental related function (Mean ± SD)	5.9 ± 3.0 (0 - 9)
Full care (0-2)	15 (16.7)
Needed assistance (3-5)	19 (21.1)
Needed supervision (6-8)	42 (45.6)
Independent (9)	15 (16.7)
Oral Health Measures	
Debris Index (Mean ± SD, Min–Max) [§]	1.8 ± 0.6 (0.5 - 3.0)
Gingival Index (Mean, SD, Min–Max) [§]	1.5 ± 0.5 (0.6 - 2.8)
Number of existing teeth (Mean ± SD, Min–Max) [§]	19.3 ± 8.2 (2 - 29)
Number of teeth with active caries (Mean ± SD, Min–Max) [§]	7.2 ± 6.9 (0 - 25)
Edentulous (n, %)	23 (25.3)

* Measured by MDS-COGS – Minimum Data Set Cognition Scale;

** Measured by DAT – Dental Activities Test.

[§]Dentate subject only

Table 2

Debris Index, gingival index, number of remaining teeth and number of teeth with caries by cognitive status and dental-related function

	Study Subjects (n = 68)							
	Debris Index	P-value	Gingival Index	P-value	No of remaining teeth	P-value	No. of teeth with active caries	P-value
Cognitive status^f								
Intact-mild impairment	1.7 ± 0.7		1.4 ± 0.5		14.7 ± 11.1		4.8 ± 6.3	
Mild-moderate impairment	1.8 ± 0.5	0.056	1.5 ± 0.6	0.017	12.2 ± 10.1	0.586	4.0 ± 4.7	0.143
Moderate-severe impairment	1.8 ± 0.6		1.5 ± 0.5		12.7 ± 11.8		4.9 ± 7.0	
Severe-very severe	2.2 ± 0.6		1.9 ± 0.6		20.0 ± 10.4		10.0 ± 9.3	
Dental-related function^g								
Independent	1.7 ± 0.7		1.5 ± 0.7		14.3 ± 10.6		5.5 ± 7.2	
Needs supervision	1.6 ± 0.6	0.013	1.3 ± 0.4	0.008	12.8 ± 11.0	0.478	3.8 ± 4.9	0.214
Needs assistance	2.0 ± 0.3		1.5 ± 0.4		17.9 ± 10.3		6.2 ± 6.9	
Full care	2.2 ± 0.6		2.0 ± 0.5		15.4 ± 12.0		8.0 ± 9.3	

^f Measured by Minimum Data Set Cognition Scale. Score 0-1 cognitively intact – mild cognitive impairment; 2-4 mild-moderate impairment; 5-8 moderate-severe impairment and 9-10 severe-very severe impairment;

^g Measured by Dental Activities Test. Score 9 Independent; 6-8 Need Assistance; Score 3-5 Need Supervision; Score 0-2 Full Care.

Table 3. Effect of cognitive impairment or dentally-related function on oral health outcome controlling for covariates

	Debris Index*			Gingival Index*			Number of remaining teeth**			Number of teeth with active caries***		
	Parameter Estimate (SE)	Confidence Interval	p value	Parameter Estimate (SE)	Confidence Interval	p value	Parameter Estimate (SE)	Confidence Interval	p value	Parameter Estimate (SE)	Confidence Interval	p value
Cognitive impairment ^f	0.05 (0.02)	(0.01, 0.09)	0.017	0.05 (0.02)	(0.02, 0.08)	0.004	0.01 (0.02)	(-0.02, 0.04)	0.498	0.06 (0.03)	(-0.00, 0.11)	0.055
Dental-related function ^g	-0.07 (0.02)	(-0.11, -0.02)	0.005	-0.06 (0.02)	(-0.09, -0.02)	0.002	-0.02 (0.02)	(-0.05, 0.02)	0.529	-0.04 (0.03)	(-0.11, 0.03)	0.225

^f Measured by Minimum Data Set Cognition Scale;

^g Measured by Dental Activities Test. A higher DAT score indicates a poor DRF function;

* Adjusted for age at enrollment, years living in the facility, gender, race and facility type;

** Adjusted for age at enrollment, years living in the facility, gender, race, facility type and dental insurance;

*** Adjusted for age at enrollment, years living in the facility, gender, race, facility type, dental insurance and the number of remaining teeth