Published in final edited form as:

Spec Care Dentist. 2018 November ; 38(6): 337–344. doi:10.1111/scd.12320.

Oral Health Trajectories in Community-dwelling Older Adults in the Last Three Years of Life

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Abstract

Background: Systemic health and physical, cognitive and social function gradually decline at the end of life. How oral health change at the end of life in community-dwelling older adults remains unknown, increasing the difficulty in treatment planning for these individuals.

Methods: 250 community-dwelling decedents of a longitudinal study were included in the analysis. Decedents' clinical and interview data collected at baseline, 18, 36, 60 and 84 month were linked to their death dates and plotted on an inverted time scale to study their oral health changes in the three years prior to death. Mixed effect models with random intercepts and slopes of months from death and socio-demographic variables were used to model the subjective and objective oral health trajectories in the last three years of life. The association of the change in the outcomes with a linear trend of months from death were assessed using the F-test.

Results: Number of missing teeth was significantly associated with a linear trend of months from death. With every month in proximity to death, the expected number of missing teeth increased by 0.03 (SE=0.004; $P<0.001$), resulting in an average of 1.08 missing teeth in three years. Among subjective outcomes, the odds of good versus poor or "neither" self-rated systemic health ($P=0.009$) and mouth appearance ($P=0.008$) significantly decreased as death approached.

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Note

The present study was conducted at the University of North Carolina.

Conclusion: While other oral health measures remained relatively stable, tooth loss and dissatisfaction with mouth appearance steadily increased in community-dwelling older adults as death approached. These changes were gradual and parallel the end-of-life general health decline.

Keywords

Oral health; End of life; Older adults; Tooth loss

INTRODUCTION

Older adults experience complex health, functional, cognitive and psychological changes at the end of life¹⁻³. These declines can start several years prior to death^{1, 4, 5} and substantially vary in persons with different functional trajectories at the end of life^{6, 7}. How these changes affect oral health remain unknown. Although dental professionals have suspected oral health may decline at the end of life, how severe these declines are and how end-of-life oral health changes differ in persons with different functional statuses are not well-understood. Consequently, dental professionals face a great challenge in caring for older adults at the end of life. Many important clinical questions (e.g., does oral health decline in parallel with end-of-life systemic health and functional declines? Do community-dwelling older adults and nursing home (NH) residents share the same or a similar oral health change pattern at the end of life? What's the best approach to address the oral health needs and prevent oral health decline for end-of-life older adults with different terminal functional trajectories?) remain unstudied. The lack of information makes clinical treatment planning for end-of-life patients difficult and raises concerns for the quality of care for these vulnerable individuals⁸.

The first step to address this challenge is to understand the impacts of the dying process on oral health and study the different oral disease patterns in older adults with different dying trajectories. On a population level, death can be classified into four groups (sudden death, terminal illnesses, advanced organ failure and frailty), each differing in the length and slope of functional decline at the end of life⁶. The different dying trajectories imply that oral health changes may also differ among individuals with different health conditions⁹. As a result of increased disease burden, physical and cognitive functional decline and psychological distress, the risk of dental caries and other oral disease can elevate in older adults at the end of life. These changes have been observed in NH residents who usually experience complex oral health decline as a result of progressive functional loss at the end of life⁸⁻¹². However, how oral health changes over time in community-dwelling older adults at the end life is virtually unknown. Given the different disease patterns and functional profiles between these two populations, it is reasonable to assume that the end-of-life oral health trajectory in community-dwelling older adults can substantially differ from that of NH residents^{6, 13}.

Knowing how oral health changes over time at the end of life, especially the “change-point” that may indicate terminal oral health decline, in community-dwelling older adults is important. It would inform dental professionals when to start palliative care and help them customize oral health interventions and clinical treatment plans to better address the oral health needs of end-of-life patients with different terminal functional trajectories. It would

also help patients, their families and other health professionals plan for oral care at the end of life.

For this reason, we conducted a retrospective longitudinal study to describe how oral health change in community-dwelling older adults in the last three years of life. We hypothesized that most of the oral health measures would significantly decline as death approached. We were also interested in whether and how the distribution of these trajectories differs in persons according to sociodemographics, using the data of the Piedmont 65+ Dental Study (PDS) and the National Death Index (NDI).

MATERIALS AND METHODS

The present study was a secondary data analysis of a longitudinal study. The study protocol has been approved by the University of North Carolina Institute Review Boards.

Study Population

Participants were drawn from the Piedmont 65+ Dental Study (PDS). The PDS was an ancillary study of the Duke Established Populations for Epidemiologic Studies of the Elderly (EPESSE), a longitudinal investigation of a random sample of more than 4100 community-dwelling people aged 65 and above in five contiguous North Carolina counties. The PDS included 818 dentate community-dwelling older adults aged 65 and above that were randomly selected from the parent study¹⁵. Among them, 8 were neither black nor white and excluded from the analysis due to the small sample size. During the 7-year follow-up, 215 participants of the PDS deceased. Thirty-five died within two years after the study was closed. These 250 deceased individuals consisted of the analytic sample of the present study.

Data Collection

After informed consent was obtained, a trained, calibrated team of dentists conducted comprehensive oral examinations, microbiological and salivary assays and interviews for the dentate participants in their home at baseline and 18, 36, 60 and 84 months. Oral examinations included assessment of dentition, dental caries, periodontal health and oral soft tissue pathology using a mirror, dental explorer and light-intensified headlamps. Oral health interviews were also conducted using structured questionnaires. The oral health interviews provided data on socio-demographic characteristics (e.g., age, gender, race, education and marital status), health behaviors (use of tobacco and use of alcohol), preventive dental behaviors (e.g., frequency of tooth brushing and use of mouth rinse), use of oral health services, history of oral pain and discomfort, and self-perceived oral and general health.

In addition to the oral health assessment, participants' physical health, functional status, medications, cognitive function, sociodemographics and mortality information were also collected through the parent study. However, since this information was typically gathered two years prior to the oral assessments, it might not truly reflect the health and functional status of the participants at the time of oral assessment, and was excluded from the analysis. Moreover, the patterns of preventive dental behaviors and use of dental services at the end of life have been discussed elsewhere¹⁴. Given that the present study aimed to describe the oral

health change patterns at the end of life, this information, together with health behaviors, were excluded from the analysis.

Determination of Timing of Oral Exams Prior to Death

Death was ascertained from the next of kin or other knowledgeable person during a subsequent PDS follow-up. The causes and dates of death were identified by linking the EPESE and NDI datasets.

Depending on their length of follow-up, decedents completed 1 to 5 oral exams and interviews. Oral exam and interview dates were recorded and linked to decedent's death date to determine the number of months prior to death when each oral exam and interview was conducted. This information was subsequently linked to the oral exam and interview data. Although the length of follow-up could last up to 7 years in some decedents, the preliminary analysis revealed that the data beyond the last three years of life was less reliable. Therefore, the analysis focused on oral health trajectories in the last three years of life.

Oral Health Measures

To describe how oral health change in the last three years of life, subjective and objective oral health measures were examined. The subjective outcomes included self-rated overall health and six self-rated oral health measures, including overall oral health, appearance of mouth, appearance of face, ability to chew, ability to taste foods, and ability to smell. This information was collected during oral health interview. The participants were asked to rate their oral and general health from these seven aspects in comparison to their peers using a 3-level scale, "good", "neither good or bad" and "bad". To assess the changes in self-rated measures qualitatively, categories of "neither good nor poor," and "poor" were combined.

The objective measures included number of missing teeth to measure the changes in dentitions, percent of decayed or filled coronal surfaces and percent of decayed or filled root surfaces to measure changes in dental caries experience adjusting for number of remaining teeth, and percent of periodontal sites with pocket depth greater than 3mm to assess changes in periodontal health. These objective measures were collected during oral examinations and described in detailed in the original reports of the PDS^{15, 16}. Briefly, the third molars were excluded during the exams. Coronal caries examinations were conducted in accordance with the criteria described by Radike¹⁷. Root surface caries was diagnosed using the visual-tactile criteria as described by Katz¹⁸ and modified to fit the criteria developed for the National Survey of Oral Health in US Employed Adults and Seniors, 1985–86¹⁹. For instance, the clinical diagnosis of root caries was based on the visual observation of a discrete, well-defined, and discolored cavitation on the root surface and the tactile finding of softness upon probing with light pressure. Hardened, discolored root surfaces due to arrested caries were not scored¹⁶. Periodontal pocket depth was taken at two sites on each remaining tooth (mid-buccal and mesiobuccal sites) using an NDR probe¹⁹, and were rounded down to the next lowest whole millimeter¹⁶.

Statistical Analysis

To describe how oral health change over time at the end of life, clinical outcomes (number of missing teeth, percent of decayed or filled coronal surfaces, percent of decayed or filled root surfaces, and percent of periodontal sites with pocket depth >3mm) were fitted using linear mixed effects models with random intercepts and slopes of months from death and socio-demographic variables (i.e., age, race, sex, education attainment, and marital status). Linear trends in expected outcomes over the 36 months period prior to death were assessed using F-tests.

Binary subjective outcomes (good versus neutral or poor) for overall body health, overall mouth health, ability to chew, face appearance, and mouth appearance were fitted using generalized linear mixed effects models with logit link and random intercepts and slopes of months from death and socio-demographic variables described above. Linear trends in the odds of a good outcome based on months from death were assessed using F-tests.

Because relatively few subjects had data at two or more visits on Taste ability (n=21) and Smell ability (n=22), fitting GLMMs was prohibitive; as an alternative statistical assessment for within-subject change in these outcomes over time, McNemar's test for paired binary outcomes was applied to determine whether the proportion of subjects with neutral or poor scores at the second measurement occasion (i.e., closer to death) was different than the proportion of subjects with neutral or poor scores at the first measurement.

All mixed models were fitted using SAS Proc Mixed for the clinical outcomes and SAS Proc Glimmix for the subjective outcomes (version 9.4). All statistical tests were deemed statistically significant based on a two-sided p-value less than 0.05.

RESULTS

Baseline characteristics of the Subjects

Compared to the survivors, the 250 decedents were older (75.7 vs. 72.3; $P<0.001$, Table 1), had less years of education (8.6 vs. 10.1, $P<0.001$) and more likely to be male (51.2% vs. 36.1%; $P<0.001$), white (58.8% vs. 53.8%; $P=0.182$), and married (59.0% vs. 52.1%; $P=0.070$). Further analysis showed that in general, individuals who died soon after an oral examination were similar to those who survived longer (data not shown).

The decedents had 14.9 missing teeth at the baseline, significantly more than that in the survivors ($P=0.005$). Dental caries experience did not differ in the decedents and survivors, but the decedents had significantly more sites with pocket depth >3mm ($P<0.001$).

How Self-rated Oral Health Measures Changed in Proximity to Death

We modeled seven self-rated oral health measures, including self-rated overall health overall oral health, appearance of mouth, appearance of face, ability to chew, ability to taste foods, and ability to smell to describe how these measures changed when death approached. With regard to subjective oral and general health measures, self-rated overall oral health and ability to chew did not change significantly in proximity to death. Controlling for age, gender, race, education and marital status, the log odds of reporting good versus neutral or

poor self-rated overall body health and mouth appearance decreased significantly with each month closer to death by 0.02 (SE=0.009; P=0.009, Figure 1a) and 0.02 (SE=0.007; P=0.008, Figure 2), respectively. Face appearance had a significant unadjusted association with time from death, but the adjusted association only showed borderline significance, having a 0.01 (SE=0.006; P=0.056) decrease in log odds of reporting good versus neutral or poor for each month closer to death. Interestingly, as they approach death, those with a middle school education or less were expected to have an increase in log odds to report having good overall body health (0.020; SE=0.010; P=0.048, Figure 1b) relative to those with greater than a high school diploma.

Intra-subject changes in self-reported ability to taste and smell were also examined. At the first measurement, 8/21 (38.1%) of subjects reported having neutral or poor taste ability, whereas at the second measurement occasion, 9/21 (42.9%) of subjects had neutral or poor taste ability (p=0.78). With respect to ability to smell, 8/22 (36.4%) subjects reported having neutral or poor smell ability at the first measurement, whereas 6/21 (28.6%) had neutral or poor smell ability at the second measurement (p=0.053).

How Objective Oral Health Measures Changed in Proximity to Death

Among the four clinical measures (i.e., number of missing teeth, percent of decayed or filled coronal surfaces, percent of decayed or filled root surfaces and percent of periodontal sites with pocket depth greater than 3mm), only the number of missing teeth had a significant linear trend based on months from death when adjusting for sociodemographic variables. For every month a participant became closer to death they were expected to have an increase in their number of missing teeth of 0.03 (SE=0.004; P<0.001, Figure 3a), resulting in a total of 1.08 incident missing teeth in the last three years of life. Additionally, Blacks are expected to have a further increase in the number of missing teeth for each month closer to death of 0.01 (SE=0.004; P=0.005, Figure 3b).

Other clinical measures including percent of decayed or filled coronal/root surfaces and percent of periodontal sites with pocket depth greater than 3mm were not significantly associated with time to death.

DISCUSSION

The present study was the first and only longitudinal study to describe how oral health of community-dwelling older adults changes over time at the end of life. It revealed that community-dwelling older adults experienced gradual but significant oral health deteriorations in the last three years of life. Most of the subjective and objective oral health measures did not change significantly along with time in the last three months of life. Yet along with systemic health decline, community-dwelling participants experience more tooth loss and were less likely to be satisfied with their mouth appearance when death approached. Although the findings of this study seem to be obvious and common senses, our study is the first study providing empirical evidence in support of these “common senses.” In fact, the findings of this study considerably differ from what we expected. As discussed, we anticipated most of the oral health measures would significantly decline over time, but found only a few measures (i.e., number of tooth loss) increased as death approached. This

discrepancy suggests that the end-of-life oral health changes may differ in persons with different health and functional statuses. Different oral intervention strategies may be needed to appropriately address oral health needs in older adults at the end of life.

While self-reported oral health and most of the objective oral health measures did not change significantly as expected, number of missing teeth increased as death approached, especially in the Blacks. On a rate of 0.03 teeth missing every month, an end-of-life participant was expected to lose 1.8 teeth in 5 years, which is higher than 1.3 teeth in functionally-dependent LTC residents and 0.8 teeth in community-dwelling older adults who are not at the end of life²⁰. Given that dental caries and periodontal disease are the main risk factors of tooth loss in older adults^{20–22}, this finding implies that in parallel with the health and functional deteriorations at the end of life, the overall oral disease burden might have increased in the participants as death approached. However, instead of saving their teeth, these individuals or their dentists tended to extract diseased teeth. While the exact reason for the increased tooth loss at the end of life remains unknown, multiple factors may contribute to this finding. First of all, community-dwelling older adult can experience chronic declines in cognitive, physical and psychosocial function as death approaches^{1, 2, 7}. Morbidity will increase and systemic health will gradually decline. These changes may occur several years prior to death^{1, 4, 5} and can potentially affect individual's oral self-care function and access to regular care, which in turn compromises oral health. However, poverty is common in old age²³. It can influence physiological responses to oral disease, health-related behaviors and decision making related to oral disease management²⁴, all of which make these individuals more likely to choose extraction -- an "easy and less costly" solution-for the diseased teeth^{25, 26}. Additionally, depression and other negative affect also progressively increase at the end of life and surge in the last 4 of years of life^{3, 27}, which can also lower participants' desires to spend resource and effort to save their teeth^{28–30}.

These findings, together with the results of previous studies^{8, 10, 11}, suggest that the end-of-life oral health change patterns distinctly differ between community-dwelling older adults and NH residents. While NH residents usually experience substantial declines in oral health prior to death^{8, 10, 11}, the oral health changes in community-dwelling older adults are usually less severe and gradual. These differences may be due to the distinct terminal functional decline patterns between these two populations. NH residents at the end of life usually have multiple chronic health conditions³¹ and experience significant, progressive functional loss prior to death¹³. The dying process of these individuals could last 1–2 years^{6, 31}, and a great majority of these individuals require substantial assistance on basic activities of daily living including oral care during this process³². However, for those relying on caregivers for oral hygiene, provision of oral care is often limited due to lack of training and guidance, time pressures, low oral health literacy, distaste for the activity, and fear of resistant behaviors^{33–36}. Consequently, oral hygiene is usually poor in these individuals, which increases the risks of dental caries, periodontal disease and other oral pathologies and initiates the cascade of oral health decline^{8, 10–12}. In contrast, all the participants of this study were community-dwelling older adults and lived in their own houses/apartments throughout the study, suggesting that they were relatively independent in function. Although these individuals might experience functional decline as death approaches, functional disability is less common and more subtle than NH residents in which about 90% of the

residents need assistance with activities of daily living (ADLs)^{7, 32, 37}. During gradual functional loss, the great majority of community-dwelling older adults can develop skills to adapt to functional impairment and maintain oral hygiene without needing help from professional caregivers until a few months prior to death⁷. Consequently, the oral health issues commonly seen in end-of-life NH residents (e.g., caries, dental pain, or infection) might not have become significantly increased before death occurred. Additionally, unlike NH residents, community-dwelling older adults are less likely to suffer advanced dementia^{7, 31}, and therefore more likely to maintain cognitive capacity to perceive and seek help for oral health problems. All of the above can help explain the end-of-life oral health discrepancy between community-dwelling older adults and NH residents.

The present study revealed that community-dwelling older adults lost their teeth at a fast rate in the last three years. This finding suggests a need to improve oral health and maintain dentition among these individuals. As discussed, as death approaches, individuals may experience substantial decline in physical health and function and increased depression and anxiety¹⁻³, all of which may increase the risk of developing oral disease, lower their desire to maintain good oral health, affect their ability to access regular oral health care, and therefore increases the risk of tooth loss. The accelerated tooth loss can impair chewing function, limit the choices of food selection and lead to malnutrition^{38, 39}, which in turn can hasten the terminal functional loss^{40, 41}. Although oral health is poor, many older adults at the end of life do not see dentists regularly^{8, 14}. Yet they still receive regular care from medical and nursing professionals who are usually not prepared to diagnose and treat oral disease. Therefore, an interprofessional collaborative practice model in which dental professionals can play an important and valuable role should be used to better address the oral health needs of persons at the end of life. While helping physicians and other healthcare providers identify and manage simple oral health issues of end-of-life patients at bedside, dental professionals can also understand the prognoses of their patients and therefore improve quality of care for these vulnerable individuals. A comprehensive approach, including managing the impact of late-life depression, addressing xerostomia, providing functionally-tailored oral care rehabilitation for persons at the end of life and need-based training for caregivers and more frequent recall, should, therefore, be used to improve oral health and reduce the risk of tooth loss in person at the end of life.

The distinct oral health change and functional decline patterns between NH residents and community-dwelling older adults⁹ also suggest that different treatment approaches should be adapted to address the oral health needs in older adults at the end of life. First and foremost, daily oral care and effective prevention should be provided to maintain oral health in these individuals, regardless of their residential status. For those experiencing progressive functional loss prior to death (e.g., NH residents with dementia or organ failure), palliative care should focus on prevention of oral pain, infection and oral health related systemic complications³. Alternatively, for community-dwelling older adults with reasonable physical function, comprehensive but conservative treatment corresponding to patient's oral disease pattern, personal preference, overall health status and functional trajectory could still be considered, given that prediction of death may be difficult in these individuals. However, cautions still need to be taken for extensive surgery or stressful treatment because organ functional reserve is usually compromised in these individuals as a result of disease and

aging. Aggressive treatment (e.g., full mouth extraction in one visit) should be avoided⁹. Also, when appropriate, conservative measures should be taken to address oral health related aesthetic concerns and personal needs.

Due to the concern regarding the reliability of the health and functional data, we excluded such information from the analysis. Not including these variables in the model did not affect our ability to study the trend of oral health changes in the last three years of life. However, given the potentially significant changes in health and function at the end of life and their impacts on oral health, their exclusion might have prevented us from understanding how health and functional decline may affect oral health trajectory at the end of life. Also, all data was collected at baseline and 18, 36, 60 and 84 month follow-up visits and were plotted on an inverted time scale to study the oral health changes in the last 3 years of life. If oral health declines took place after the data collection, we might not be able to capture these changes. Additionally, the small sample sizes of subjects with multiple measurements for ability to taste and smell limited power to detect within-subject change over time for these outcomes. It also limited our ability to evaluate for a “change-point” in trends either within the three year period or with respect to trends prior to three years. Finally, this study was based on existing data that were originally collected in the 1990s. The sociodemographic characteristics of the study participants might differ from the current generation of older adults. As a result of economic development, better education, improved public health education and advance in oral health care, the current generation of older adults is more likely to value oral health and preventive dental care. As compared to the study cohort, they may experience a different oral health trajectory at the end of life. For this reason, caution should be used when generalizing the results of this study to the current elderly population.

In conclusion, while other oral health measures remained relatively stable, tooth loss steadily increases in community-dwelling older adults as death approaches. These changes were gradual and parallel the end-of-life general health decline.

Acknowledgement

This study was supported by K23DE022470 from the National Institute of Dental and Craniofacial Research.

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Figure 1.
Self-reported Overall Health by Time to Death

Figure 2.
Self-reported Mouth Appearance by Time to Death

Figure 3.
Number of Missing Teeth by Time to Death

Table 1

Baseline characteristics of decedents and survivors

Characteristic	Decedents (N=250)	Survivors (N=560)	P value
Sociodemographics			
Age, mean (SD)	75.7 (6.62)	72.3 (4.98)	<0.001
Male, No. (%)	51.2	36.1	<0.001
Black, No. (%)	41.2	46.2	0.182
Year of education, mean (SD)	8.6 (4.75)	10.1 (4.36)	<0.001
Married, No. (%)	59.0	52.1	0.070
Clinic oral health measures			
Number of Missing Teeth, mean (SD)	14.9 (8.20)	13.2 (7.81)	0.005
Percent of decayed/filled coronal surfaces, mean (SD)	16.0 (15.61)	15.4 (12.98)	0.692
Percent of decayed/filled root surfaces, mean (SD)	10.6 (15.36)	8.2 (11.08)	0.120
Percent of with periodontal sites with Pocket depth >3mm, mean (SD)	11.0 (15.94)	7.4 (12.62)	<0.001