Upper extremity disabilities in Americans and disparities in periodontal health

Madhurima Ganguly

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Annette L. Fitzpatrick
Christy McKinney

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Abstract

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Chair of the Supervisory Committee:
Annette L. Fitzpatrick, Research Professor
Department of Epidemiology

Objective: To examine the association between upper extremity disability with periodontitis and the severity of periodontitis in adults aged 30 years or above residing in the United States.

Methods: Study design was a cross-sectional observational study using the National Health and Nutrition Examination Survey (NHANES) data from 2009-2012. Periodontitis severity was classified into mild, moderate and severe. Disability was measured using an activities of daily living (ADL) questionnaire. Multinomial and multivariate logistic regression analyses were performed.

Results: Prevalence of upper extremity disability was 33.5% and of periodontitis was 59.2%. Increased odds of having mild and severe periodontitis were found for grasping and dressing difficulty in unadjusted but not adjusted estimates. When periodontitis was classified as a binary outcome, significantly higher odds of having periodontitis was associated with dressing difficulty (adjusting for age) but was not significant in the fully adjusted model. No significant associations were found for eating, lifting and reaching with periodontitis.

Conclusion: There were no significant associations between upper extremity disability and periodontitis in this adult sample from NHANES.

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BACKGROUND

Periodontitis is the chronic inflammation of the hard and soft tissues supporting a tooth. In the United States, the prevalence of periodontitis is 47% among adults greater than 30 years of age (Meyer, Yoon, & Kaufmann, 2013). Periodontitis has negative impacts on many aspects of daily living and quality of life, affecting confidence, social interactions and ability to eat (O'Dowd, Durham, McCracken, & Preshaw, 2010).

Periodontitis is associated with systemic illness such as cardiovascular diseases, bacterial pneumonia, and diabetes mellitus (Li, Kolltveit, Tronstad, & Olsen, 2000). Patients with generalized and localized periodontitis have higher median C-reactive protein levels (a risk factor for cardiovascular disease and marker for systemic inflammation) than those without periodontitis (1.5 and 1.3 versus 0.9 mg/L, respectively, $p = 0.03$) (Loos, Craandijk, Hoek, Wertheim-van Dillen, & van der Velden, 2000). In adjusted analysis, the presence of moderate or severe chronic periodontitis increased the risk of community acquired pneumonia [odds ratio (OR) = 4.4, 95 % confidence interval (CI) = 1.4-13.8]. Clinical attachment loss (CAL) of >=5 mm, a measure of periodontal disease, is also associated with a fourfold increased risk of diabetes (Choi et al., 2011). Studies show that improving periodontal conditions improves diabetes, cardiovascular risk scores as well as pneumonia (Singh, Kumar, Kumar, & Subbappa, 2008; D'Aiuto et al., 2006; Yoneyama et al., 2002).

Several modifiable and non-modifiable risk factors for periodontitis have been identified. The non-modifiable risk factors include genetics, host response, and ageing. Reported modifiable risks factors include smoking, diabetes and psychological stress (Timmerman & van der

Weijden, 2006). In addition, one study has shown that physical disability did not increase the risk of periodontal diseases (Jette, Feldman, & Douglass, 1993). However, there have not been many studies which have looked into the association between physical disability and periodontitis and this relationship has not been fully explored.

Disability is defined as the difficulty or dependency in carrying out activities essential to independent living; including essential roles and tasks needed for self-care, living independently in a home and desired activities important to one's quality of life (Adams, Hendershot, & Marano, 1999). A report by the United States Census Bureau shows that 18.7 % of the non-institutionalized civilian population has a communicative, physical, or mental disability (Brault, 2012).

Functional activity is a key component of the overall health status of an adult, particularly for older adults. Individuals with disability may have poor physical health and mental health (Anderson, Deokar, Edwards, Bouldin, & Greenlund). Having a functional limitation is also an independent risk factor for increased healthcare costs (Lubitz, Cai, Kramarow, & Lentzner, 2003). Functional limitation is sometimes measured using scales that focus on activities of daily living (ADL) (Spector & Fleishman, 1998) . The level of difficulty related to the ADLs determines an individual's extent of functional limitations. A study reported that Medicare enrollees incurred higher health care costs as the number of their physical activity limitations increased (Chan et al., 2002). Individuals having difficulty with 5-6 ADLs had a higher cost ratio than those having no difficulty with ADL (Cost ratio=2.3 [95% CI, 1.7-3.2]) (Chan et al., 2002). Physical disability has also been reported to be associated with the dental care that individuals

receive. Individuals with physical disability had a 57% higher odds ($p<0.0001$) of having unmet dental treatment (Mahmoudi & Meade, 2014).

Studies have shown that medically compromised individuals are at an increased risk of poor oral health and that oral health related quality of life is adversely affected in people who have chronic mental and physical conditions or physical disabilities (Locker, Matear, Stephens, & Jokovic, 2002; Paunovich, 1994). Individuals who are intellectually disabled are more likely to have periodontal disease than non-disabled individuals (Anders & Davis, 2010). Furthermore, the prevalence of untreated caries, periodontitis and edentulism was 32.2%, 80.3% and 10.9%, respectively, among intellectually and developmentally disabled adults compared to 23%, 47% and 8% in non-disabled adults (Morgan et al., 2012; Beltrán-Aguila et al., 2005).

Although there are studies showing positive associations between disability and dental needs, most studies have primarily looked into the association of intellectual disability and overall oral health in the elderly population. There is a study which has looked into the effect of physical disability on dental caries, edentulism, and periodontal disease in community dwelling elderly individuals (Jette et al., 1993) but to our knowledge, no studies have looked into the effect of physical disability on periodontitis in non-institutionalized adults.

Good oral hygiene practice including tooth brushing and flossing has been correlated to manual dexterity. Manual dexterity of a preferred hand was significantly correlated with all oral hygiene scores whereas no significant correlations between a non-preferred hand and oral hygiene scores were found. (Shaw, Shaw, & Foster, 1989; Kenney, E. B., Saxe S.R, 1976). Since there is a strong association between manual dexterity and oral hygiene status, individuals with upper extremity disabilities might have impaired ability to brush and floss their teeth – which could

lead to periodontitis. Physical limitations have not been well explored as an obstacle to receiving dental care and access to dental treatment, which may also lead to periodontitis.

Periodontitis is largely preventable if adults practice effective self-care and have access to preventive and therapeutic dental services (Löe, 2000). Understanding the relationship between upper extremity disability and periodontal diseases may help in designing preventive measures to reduce the prevalence of periodontitis in persons with such disabilities by focusing specifically on their needs and interventions to improve self-care. It could also help reduce the expenditure of their periodontal care by focusing on prevention rather than expensive treatments.

OBJECTIVES AND RESEARCH QUESTION

Overall Aim

The overall purpose of the study is to determine if upper extremity disability affects periodontal health in American adults aged 30 years or older.

Specific Objectives

1. To estimate the association between the presence of overall upper extremity disability, defined by having difficulty with one or more of the following activities - eating, dressing, grasping, lifting and reaching, with periodontitis and severity of periodontitis in Americans aged 30 years or older using the NHANES data from 2009-2012.

2. To estimate associations of difficulty with eating, dressing, grasping, lifting, and reaching individually with periodontitis and severity of periodontitis.

Hypothesis

We hypothesize that the prevalence of periodontitis and the severity of periodontitis is higher among those with any upper extremity disability compared to those with no disability. We also hypothesize that the prevalence of periodontitis and severity of periodontitis is higher for individuals having difficulty with each of the above-mentioned activities separately.

METHODS

Study design

We used data from two waves of the National Health and Nutrition Examination Survey (NHANES) in the US (2009-2012). NHANES is a cross sectional observational study designed to assess the health and nutrition status of the US non-institutionalized population. The survey examines a nationally representative sample of approximately 5,000 participants each year and was initiated in the early 1960's. Participants are located in counties across the country, 15 of which are visited each year. The interview includes demographic, socioeconomic, dietary, and health related questions. The examination component consists of medical, dental, and physiological measurements, as well as laboratory tests administered by highly trained medical personnel.

We pooled 2 waves of publicly available NHANES data (2009-2010 and 2011-2012) for analysis. Full mouth periodontal examination had not been conducted in NHANES before 2009-2010 and so we limited our study to these 4 years of data (2009-2012).

Study population

Of the 20,293 participants in the two waves of data selected for this study, 9,743 were 30 years of age or older and eligible for our study. Of those who were 30 years of age and older, we sequentially excluded participants who were edentulous (n=2,266), did not complete periodontal examination (n=382) and/or had missing information (n=3,859) on all of the physical functioning questions of interest. The final sample size of the eligible participants was 3,236 representing a weighted population of 110.3 million civilian non-institutionalized US adults.

Data Collection in the NHANES

All NHANES survey participants in our study were eligible for the physical functioning questionnaire conducted by NHANES personnel and were asked about their ability to work. The questions were asked in the household interview as a part of a computer-assisted personal interview (CAPI).

The NHANES periodontal examination was conducted by dentists having a D.D.S / D.M.D degree and licensed to work in at least one US state. Medical health-screening questions were asked to study participants by the oral health examiners prior to the oral health examination. Periodontal examination was a full-mouth, six-site per tooth assessment. Similar protocols were used in the 2009-2010 and 2011-2012 waves. Exams were conducted in mobile examination centers (MECs). Periodontal data was recorded directly onto a computerized data collection form after the examinations.

Periodontal attachment loss found in the periodontal examination data was measured at six surfaces (mesio-facial, mid-facial, disto-facial, mesio-lingual, mid-lingual and disto-lingual) of all the upper and lower teeth excepting third molars. A Hu-Friedy periodontal probe with graduations of 2 mm, 4 mm, 6 mm, 8 mm, 10 mm, and 12 mm was positioned parallel to the long axis of the tooth at each site. Each measurement was rounded to the lowest whole millimeter. Measures were recorded directly into an NHANES oral health data management program that instantly calculated attachment loss as the difference between probing depth and gingival recession.

Exposure

The main exposure of interest is upper extremity disability. We measured upper extremity disability using the ADL questionnaire (Jensen, Saunders, Thierer, & Friedman, 2008). The physical functioning section (PFQ) in the NHANES provides self-reported data on functional limitations caused by long-term physical, mental, and emotional problems or illness. The NHANES ADL scale is reliable and correlates well with internal measures of functioning and disability (Cook et al., 2006). It has previously been used to assess an individual's level of disability (Wade & Collin, 2009).

We chose the ADLs affected by upper extremity that were included in the PFQ of the NHANES because we anticipated that individuals having difficulty with use of arms, hands or shoulders might have trouble brushing and flossing, which may lead to build up of plaque and hence periodontitis. The survey participants were asked to complete an interview and report the level of difficulty that they had with various ADLs. The responses included - "no difficulty", "some difficulty", "much difficulty", "unable to do" or "do not do this activity". The activities we

considered were (1) eating, (2) dressing, (3) using fingers to grasp small objects, (4) lifting or carrying, and (5) reaching up over head. For each activity, the ADLs were categorized as no disability (reported 'no difficulty' in the ADL) or having the disability (reported 'some difficulty', 'much difficulty', 'unable to do'). We defined any disability as reporting of 'some difficulty', 'much difficulty' or 'unable to do" for at least one of the above mentioned activities. Those reporting "no difficulty" with all of the upper extremity disability activities were classified as having no disability.

Outcome

Our primary outcome is periodontitis. Periodontal measurements were used to classify participants as having a mild, moderate, or severe disease by using updated case definitions for surveillance of periodontitis (Eke, Page, Wei, Thornton-Evans, & Genco, 2012) . In the past, due to the lack of a universally accepted case definitions for periodontitis surveillance, there were challenges in determining and comparing prevalence estimates of periodontitis across surveys. Hence the Center for Disease Control (CDC) in partnership with the American Academy of Periodontology (AAP) came up with a case definition of periodontitis for surveillance-based studies. This definition is now broadly accepted and hence we used it for this study.

According to this definition, severity is based on the degree of clinical attachment loss (CAL) and probing depth (PD). CAL is the difference between the PD and the amount of gingival recession. Severe periodontitis was defined as having two or more interproximal sites with ≥6 mm CAL (not on the same tooth) and one or more interproximal sites with ≥5 mm PD. Moderate periodontitis was defined as two or more interproximal sites with ≥4 mm CAL (not on the same tooth) or two or more interproximal sites with PD of ≥5 mm (not on the same tooth). Mild

periodontitis was defined as two or more interproximal sites with ≥3 mm CAL and two or more interproximal sites with ≥4 mm PD (not on the same tooth) or one site with ≥5 mm PD (Eke et al., 2012). Overall, the participant was classified as having 'any periodontitis' if he/she qualified to have either mild, moderate or severe periodontitis; all others were classified as not having periodontitis.

Covariates

In addition to the primary exposure (upper extremity disability) and outcome (periodontitis), we considered covariates that may confound or modify the exposure-outcome relationship. The variables available in NHANES most relevant for our study questions include: age, gender, race, education, smoking status, prevalence of diabetes mellitus and tooth count.

The definitions for each have been provided below:

1. **Age** in years at screening available in the demographic data set. We classified age into categories 30-39, 40-49, 50-59, 60-69, 70-79, and 80 years and above.

2. **Sex** classified as male and female.

3. **Race/Hispanic origin** derived from the demographic data set and classified into White Non-Hispanic, Black Non-Hispanic, Mexican American, Other Hispanic, and Other races including multiracial.

4. **Education level** available in the demographic file classified into: Less than 9^{th} grade, 9^{th}-11^{th} grade with no high school diploma, high school, some college education, and college graduate.

5. **Diabetes**: Self-reported diabetes from the diabetes file, available in the questionnaire data set. The participants were asked if their doctor had ever told them that they have diabetes. They were classified as diabetic, non-diabetic or borderline diabetic. We did not use objective measures such as plasma fasting glucose and insulin since many participants in our sample did not have these laboratory tests completed.

6. **Smoking status** obtained from the smoking file in the questionnaire data set. Data were classified as :

    - Current cigarette smokers who had smoked >=100 cigarettes in their lifetime and is currently a smoker

    - Former smokers who had smoked > or =100 cigarettes but did not currently smoke

    - Never smokers who had not smoked > or =100 cigarettes in their lifetime.

7. **Tooth Count**: We created a variable for the total tooth count (which is the total number of teeth currently present in the mouth of the participant) which was available in the data set.

Causal Diagram

The variables in this study are presented in the form of a causal diagram (Figure 1). As described in the methods section, exposure is upper extremity disability measured with the help of ADLs and its relationship to the outcome periodontitis and the other covariates have been presented.

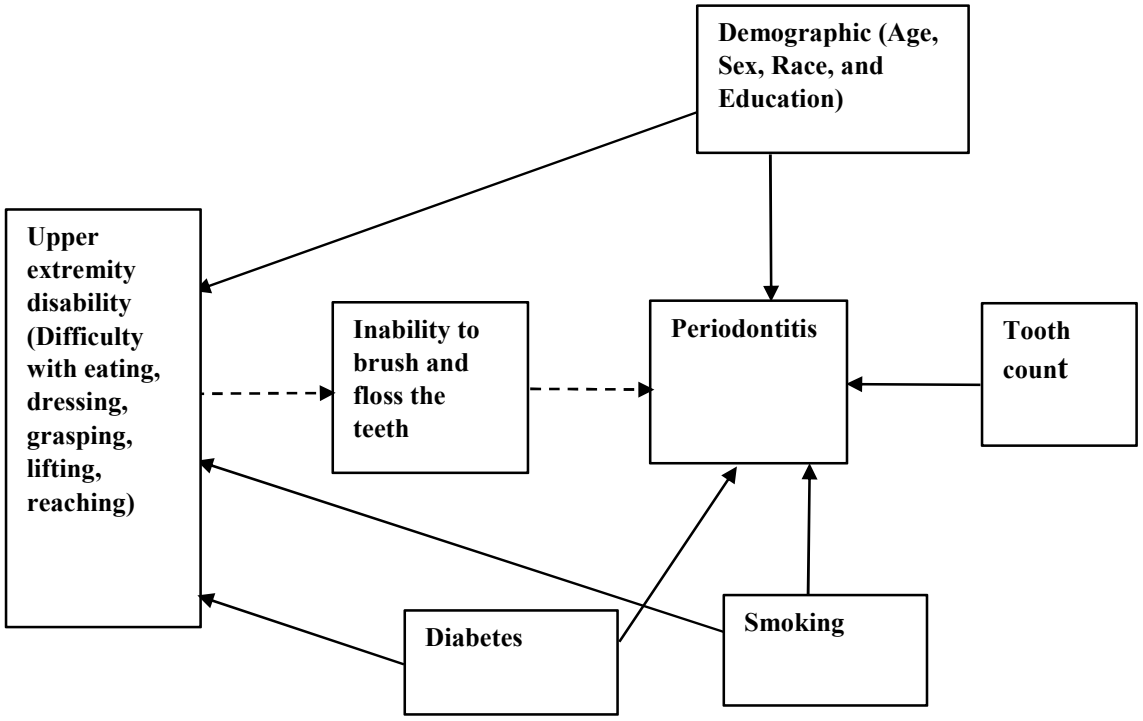

Figure 1: Causal diagram with exposure (upper extremity disability measured by ADL), outcome (periodontitis), and the other covariates (age, sex, race, education, smoking, diabetes and tooth count)

Statistical Analysis

We conducted descriptive analyses to describe the characteristics of the study population. We calculated frequencies and percentages for categorical variables. We reported the descriptive statistics stratified by age (below or equal to or above 65 years), periodontitis status (yes/no) and disability status (yes/no). NHANES uses a complex multi-stage probability sampling technique, thus we calculated both the un-weighted and the weighted (to account for the complex sample survey design) proportions. We conducted chi-square tests to determine differences between the groups. We conducted three independent analyses to estimate associations between periodontitis

and upper extremity disability. The first analysis looked at the magnitude of association of each of the upper extremity ADL (eating, dressing, grasping, lifting and reaching) (yes/no) with the severity of periodontitis (mild/moderate/severe) using multinomial logistic regression. The second analysis was conducted to look at the association of disability (yes/no) with periodontitis (yes/no) using binary logistic regression. The third analysis looked at the association between periodontitis as a binary variable (yes/no) and each ADL separately: eating, dressing, grasping, lifting and reaching (yes/no) using binary logistic regression. We reported the unadjusted ORs, ORs adjusted for age only, and ORs adjusted for all confounders (age, race, gender, education, smoking, diabetes, and tooth count) along with 95% CI and p-values for all the three analyses. The confounding variables were selected based on our causal diagram (Fig 1).

All statistical tests were 2-sided conducted with an alpha level of 0.05. Survey analysis were conducted using 'svy' command in Stata. All statistical analyses were completed using Stata-13 (StataCorp.2013. Stata Statistical Software: Release 13. College Station, TX: StataCorp LP)

Supplemental Analysis:

Since our coding algorithm for periodontitis was complex, we performed a supplemental analysis by cross checking results found in 2 published articles that used the same periodontitis definition we used and which were also based on the NHANES data set. The first was an article by the CDC included in the CDC Health Inequalities and Health Disparities Report. This study estimated the prevalence of periodontitis among adults greater than 30 years of age using the NHANES dataset from 2009-2010 (Eke et al., 2012). Because the coding algorithm for periodontitis involved extensive coding, we replicated their findings using their data set and the same eligibility criteria described in their study but applying the analytic commands for

periodontitis used in our study (the definition for periodontitis was the same in both the studies) to ensure accuracy of our measure. The second article that we compared to examine associations between periodontitis and glycemic control in diabetes using NHANES 2009-2012 data. (Garcia et al., 2014). We replicated their study population characteristics comparing periodontitis status using the same definition with selected factors using our analytic commands.

RESULTS

We had 3,236 eligible participants from the two waves of the NHANES (2009-2012), out of which 52.7%, (n =1,704) adults were 30-64 years. Those 30-64 years (adults) were more likely to be black non-Hispanic and Mexican American and to have some college education compared to those greater than 65 years of age (seniors) (Table 1). The prevalence of smoking was more than three times higher for adults less than 65 whereas diabetes was slightly more prevalent among seniors. More adults less than 65 years of age reported having difficulty performing the upper extremity activities of daily life including dressing, grasping and lifting than seniors (Table 1).

The prevalence of periodontitis was 66.4% (n=2,149). Individuals with periodontitis were more likely to be older; to be males; to be black non-Hispanic and Mexican American; to have less than 9th grade education; to be diabetic, and to be current smokers compared to those without periodontitis (Table 2). There were no statistically significant differences in the prevalence of eating, dressing, grasping, lifting or reaching difficulty between the periodontitis and non-periodontitis groups (Table 2).

Of the 3,236 participants, we identified 1,220 (37.7%) who meet our definition of disability (Table 3). Participants with disability were more likely to be younger; to be female; to be Black Non-Hispanic, Mexican American or other Hispanic; have less than a high school education; be diabetic; and be current smokers than non-disabled participants. There was no statistically significant difference in the proportion of participants having periodontitis based on overall disability status.

Table 4 presents unadjusted and adjusted (for age, race, gender, education, smoking, diabetes and tooth count) odds ratios for the severity of periodontitis with each upper extremity ADL. The odds of having mild or severe periodontitis was higher for those with eating difficulty compared to those without eating difficulty but these estimates lacked statistical precision. None of the unadjusted or adjusted associations were statistically significant. (Table 4).

In unadjusted analysis, participants with dressing difficulty had a statistically significant 1.6 times higher odds of both mild and severe periodontitis .None of the adjusted associations with this ADL were statistically significant (Table 4).

Individuals with grasping difficulty had a statistically significant 1.7 times higher odds of having mild periodontitis and a 1.4 times higher odds of having severe periodontitis. None of these associations remained statistically significant after adjusting for age, race, sex, education, diabetes, smoking and tooth count.

Subjects having reaching and lifting difficulty had a higher odds of developing mild periodontitis (in the unadjusted and the adjusted model) but none of these associations were statistically significant (Table 4).

Of the 3,236 participants, 1,220 had difficulty with at least one of the 5 ADLs: eating, dressing, grasping, lifting and reaching: 13.2% (n =161) had eating difficulty, 33.8% (n=412) had dressing difficulty, 41.9% (n=512) had grasping difficulty, 60.8% (n=742) had lifting difficulty and 47.7% (n=582) had lifting difficulty (Table 5). These groups were not mutually exclusive. We found no statistically significant association between periodontitis (yes/no) and overall disability (yes/no), with or without controlling for the other covariates (age, sex, race, gender, diabetes, smoking and tooth count). After conducting the regression analysis for each of the ADLs separately with periodontitis (yes/no), we found a 1.2 times higher odds of having periodontitis in subjects who have dressing difficulty. The association was stronger after adjusting for age [OR=1.3 (1.0-1.6), p=0.03], but was non-significant after adjusting for the other covariates. There was an increased odds of periodontitis associated with grasping, but it was not statistically significant. Lifting and reaching difficulty were also not significantly associated with risk of periodontitis. (Table 5).

The supplemental analysis shows that our operational definition of periodontitis and other covariates are consistent with the results of the two published articles that used the same definition of periodontitis and the same years of NHANES data set (Tables 6 and 7).

DISCUSSION

In this study designed to evaluate associations between upper extremity disability and periodontitis, we estimated the prevalence of any upper extremity disability to be 33.5% (about 36 million people) in adults 30 years or older residing in the United States in 2009-2012. About 59.2% of these adults had periodontitis (approximately 66 million) in 2009-2010 with 5.4%

being mild, 42.9% being moderate, and 10.9% being severe. We also found that seniors (aged 65 and older) reported less difficulty with at least one of the upper extremity activities compared to the adults aged 30-64 years (33.42% versus 41.5%).

Our study did not provide evidence for an association between difficulty with ADLs and periodontitis. Although we found increased odds of having periodontitis with eating, reaching and lifting disability, the associations were not statistically significant. Most of the increased ORs of having mild and severe periodontitis associated with grasping and dressing difficulty versus no difficulty were observed for unadjusted and not adjusted estimates. This suggests that adjusted associations were attenuated due to confounding by other covariates. When periodontitis was classified as a binary outcome, we found significantly higher odds of having periodontitis associated with dressing difficulty (adjusting for age) but no significant association with eating, grasping, lifting or reaching difficulty.

A previous study reported a 47.2% prevalence of periodontitis in the US population (Thornton-Evans et al., 2013) using the NHANES data. This is lower than our findings, but our study was based on the 2009-2012 data and our inclusion criteria of participants were different than theirs. Similar to our study results, Jette et al. (1993) reported no association between periodontitis and physical disability in bathing, dressing, using and getting to toilet, getting in and out of bed, eating, walking and getting outside. The only ADL in common between our study and theirs was dressing with which we found a significantly increased odds of severe periodontitis in the unadjusted model. This association, however, was no longer significant when we adjusted for demographics and comorbidities. Even though our findings were similar to Jette et al. (1993), they did not evaluate severity of periodontitis and their cutoff for defining periodontitis (>4 mm

PD) was different from our study. No other studies to our knowledge have investigated associations between physical disabilities and periodontitis.

There are several explanations that may be related to the lack of association between periodontitis and upper extremity disability in our study. As noted above, seniors reported significantly less difficulty in carrying out upper extremity ADLs than younger adults - a finding that was unexpected. This result might indicate survival or selection bias in the sample. This could occur if the seniors who agreed to participate in NHANES were more functional than those who did not enroll and could reflect a healthy cohort bias only for the older adults. Although we adjusted for age in our models, residual confounding could still be present and have affected our overall findings.

Another reason for the null results that we found might involve the use of electric toothbrushes for maintaining oral hygiene. Use of an electric toothbrush is more effective than a manual toothbrush in controlling plaque and gingivitis, a major cause of periodontitis (Stoltze & Bay, 1994). Because the electric toothbrush is recommended for people with physical limitation or reduced manual dexterity (Ciancio, 2002), it is possible that NHANES participants with ADL difficulty may have been more likely to use electronic toothbrushes than the non-disabled population. We did not have any information on the use of electric toothbrush available in NHANES.

An additional reason for our results might be that the disabled people were receiving help from caregivers who were responsible for their better oral health. A study has shown that oral hygiene quality is correlated to the type and availability of caregivers. (Cumella, Ransford, Lyons, & Burnham, 2000). Data on the availability of care givers were also unavailable in NHANES.

Another measure, the Instrumental Activities of Daily Living (IADL), has sometimes been used to account for the more complex activities that are needed to successfully live independently such as managing finances, shopping, handling transportation etc. A study reported that individuals with high IADL scores (7–8 indicating better functional activity) had 2.7 times higher odds of brushing their teeth at least twice a day of [95%(CI) 1.1–6.8] and 2.8 times higher odds of having good oral hygiene[95%CI: 1.0–8.3] when compared with participants with low IADL scores (≤6 indicating poor functional activity) (Komulainen et al., 2012). In this study, it is also possible that persons who were able to conduct instrumental activities such as managing finances, etc., had better cognitive function that those who could not do these tasks (Barberger-Gateau et al., 1992). Several studies have found that having mental or cognitive disabilities is related to increased periodontal diseases (Gabre, Martinsson, & Gahnberg, 2001; Anders & Davis, 2010). Measurement of cognitive abilities, however, was not addressed in the IADL study.

The Komulainen et al. (2012) study also reported that functional status of the hand, measured by handgrip strength, is not an important determinant of oral self-care among the home-dwelling elderly. This finding is similar to our results that there was no increased odds of having periodontitis with poor upper extremity function as measured by ADLs. In contrast to the Komulainen et al. (2012) study, another study reported that individuals with poor hand function (according to the Dominant Hand Purdue test) harbored significantly more dental plaque after adjustment for age, sex, and cognitive status (Padilha, Hugo, Hilgert, & Dal Moro, 2007). While it is possible that hand function as measured by the Dominant Hand Purdue test is a better measurement than grip strength in this context, it is still unclear why these difference occurred.

STRENGTHS AND LIMITATIONS

A strength of this study is the use of a large dataset combining two nationally representative NHANES survey waves. The NHANES represents a well-designed community surveillance of health risk factors and outcomes using standardized definitions and trained staff for conducting the survey. The application of a full-mouth periodontal examination protocol and probing of six sites on a tooth for both PD and AL also optimizes the potential to capture true disease. Furthermore the use of the definition of periodontitis recommended by the CDC-AAP for analysis of surveillance data makes it convenient to compare our results to other studies (Eke et al., 2012). We have used ADLs in our study, which is a validated measure of disability (Cook et al., 2006). We have also presented weighted proportions of the disease in this study which is representative of the prevalence in the population.

This study also has some limitations. As the data analyzed here was cross-sectional, we cannot determine the temporality of disability and periodontitis. Although we assumed difficulty with upper extremity ADLs (a risk factor) to precede development of periodontitis (outcome), this assumption cannot be confirmed. The full mouth periodontal examination was not conducted in NHANES surveys before 2009. Hence we could only include 4 years (2009-2012) of data for analysis. It should also be acknowledged that ADLs represent a subjective report of disability which might have led to misclassification of the exposure. Cognitive disability was not addressed due to unavailability of data. Possible explanations for our results are increased use of electric toothbrushes and availability of care givers for the disabled population but this hypothesis could not be validated.

CONCLUSION

We conclude that there is no significant association between upper extremity disability and periodontitis in the NHANES sample that we evaluated in this study. Due to potential selection bias and other factors, it is not possible to generalize beyond populations similar to those enrolled in NHANES. However, we found that the prevalence of periodontitis was slightly higher in the disabled population than in the normal population represented here. Further studies are needed to determine the cause of a higher prevalence of periodontitis in disabled compared to non-disabled adults. Additional studies would be enhanced using objective measures of disability such as grip strength or hand function tests in addition to subjective measures in non-institutionalized population to confirm these findings about periodontitis.

Periodontitis is preventable and curable (Greenstein, 2002). Factors associated with the prevention and cure of periodontitis should be explored and preventive dental care programs should be made an integral part of the preventive health services to make dental care accessible to everyone including disabled individuals.

TABLES

Table 1: Characteristics of NHANES (2009-2012) study population according to age.*

	Age: 30-64 years(n=1704)			Age: 65 years and above(n=1532)			
Characteristics	**Un-weighted (N)**	**Un-weighted proportion (%)**	**Weighted proportion † (%)**	**Un-weighted (N)**	**Un-weighted proportion (%)**	**Weighted proportion † (%)**	**p-value‡**
Sex							p=0.29
Male	832	48.8	49.2	776	50.7	46.6	
Female	872	51.2	50.8	756	49.4	53.4	
Race							p<0.001
White Non-Hispanic	671	39.4	69.8	841	54.9	80.0	
Black Non-Hispanic	456	26.8	13.0	295	19.3	7.7	
Mexican American	242	14.2	6.5	136	8.9	3.2	
Other Hispanic	198	11.6	5.1	140	9.1	3.7	
Other races including multi racial	137	8.0	5.6	120	7.8	5.4	
Education							p<0.001
Less than 9th Grade	187	11.0	5.7	223	14.6	7.8	
9th-11th Grade	283	16.6	12.7	234	15.3	11.1	
High School	414	24.3	23.6	330	21.5	23.4	
Some college	508	29.8	32.7	388	25.3	28.0	
College Graduate	309	18.1	25.3	353	23.0	29.5	
Diabetes status							p=0.05
Diabetes	318	18.7	13.8	338	22.1	19.3	
No Diabetes	1334	78.3	83.0	1137	74.2	77.2	
Borderline	50	2.9	3.2	56	3.7	3.4	
Smoking status							p<0.001
Never smokers	793	46.5	47.2	799	52.2	52.0	
Current smokers	483	28.4	26.3	124	8.1	7.2	
Former smokers	428	25.1	26.5	609	39.8	40.8	
ADL							
Eating Difficulty							p=0.13
Yes	94	5.5	4.7	67	4.4	3.4	
No	1609	94.4	95.3	1465	95.6	96.6	
Dressing Difficulty							p<0.001
Yes	268	15.8	13.5	144	9.4	7.4	
No	1434	84.2	86.5	1387	90.6	92.6	
Grasping Difficulty							p<0.001
Yes	308	18.0	17.6	204	13.3	12.9	
No	1396	81.9	82.5	1328	86.7	87.1	
Lifting Difficulty							p<0.001
Yes	454	26.9	20.6	288	18.8	15.9	
No	1232	73.1	79.4	1215	79.3	84.0	
Reaching Difficulty							p<0.001
Yes	363	21.4	11.6	219	14.3	11.7	
No	1336	78.6	82.4	1308	85.7	88.4	

*Some of the numbers might not add up to the total numbers due to missing values.
† Using survey weights to account for complex sample survey design.
‡ p- value from Chi-square test

Table 1: Characteristics of NHANES (2009-2012) study population according to age.*(continued)

	Age: 30-64 years(n=1704)			Age: 65 years and above(n=1532)			
Characteristics	**Un-weighted (N)**	**Un-weighted proportion (%)**	**Weighted proportion † (%)**	**Un-weighted (N)**	**Un-weighted proportion (%)**	**Weighted proportion † (%)**	**p-value‡**
Disability							p<0.001
Yes	708	58.5	36.4	512	33.4	29.7	
No	996	41.5	63.6	1020	66.6	70.3	
Periodontitis							p<0.001
Yes	1054	61.9	52.9	1095	71.5	67.4	
No	650	38.2	47.1	437	28.5	32.6	
Periodontitis Severity							p<0.001
No periodontitis	650	38.2	47.1	437	28.5	32.6	
Mild	98	5.8	6.5	52	3.4	4.0	
Moderate	685	40.2	35.4	829	54.1	52.5	
Severe	271	15.9	11.0	214	14.0	10.9	

*Some of the numbers might not add up to the total numbers due to missing values.
† Using survey weights to account for complex sample survey design.
‡ p- value from Chi-square test

Table 2: Characteristics of NHANES (2009-2012) study population according to periodontal status.*

	No periodontitis (n=1087)			Periodontitis(n=2149)			
Characteristics	**Un-weighted (N)**	**Un-weighted proportion (%)**	**Weighted proportion † (%)**	**Un-weighted (N)**	**Un-weighted proportion (%)**	**Weighted proportion † (%)**	**p-value‡**
Age							p<0.001
30- 39	139	12.8	11.9	77	3.6	4.6	
40-49	129	11.9	12.4	189	8.8	10.6	
50-59	115	10.6	13.9	280	13.0	14.4	
60-69	415	38.2	40.2	872	40.6	38.7	
70-79	207	19.0	15.9	456	21.2	19.9	
>=80	82	7.5	6.0	275	12.8	11.9	
Sex							p<0.001
Male	405	37.3	38.3	1203	56.0	54.8	
Female	682	62.7	61.8	946	44.0	45.2	
Race							p<0.001
White Non-Hispanic	594	54.7	80.5	918	42.7	69.9	
Black Non-Hispanic	216	19.9	8.4	535	24.9	12.2	
Mexican American	83	7.6	2.9	295	13.7	6.5	
Other Hispanic	111	10.2	3.7	227	11.0	5.1	
Other races including multi-racial	83	7.64	4.5	174	8.1	6.2	
Education							p<0.001
Less than 9^{th} Grade	76	7.0	3.7	334	15.5	8.62	
9^{th}-11^{th} Grade	133	12.2	8.7	384	17.9	14.2	
High School	238	21.9	21.3	506	23.6	25.0	
Some college	341	31.4	31.1	555	25.8	30.4	
College Graduate	296	27.2	35.1	366	17.0	21.6	
Diabetes status							p<0.001
Diabetes	168	15.5	12.1	488	22.7	19.0	
No Diabetes	878	80.8	83.8	1593	74.1	78.2	
Borderline	40	3.7	4.1	66	3.1	2.7	
Smoking status							p<0.001
Never smokers	621	57.1	57.1	971	45.2	43.9	
Current smokers	145	13.3	10.8	462	21.5	22.9	
Former smokers	321	29.5	32.1	716	33.3	33.2	

*Some of the numbers might not add up to the total numbers due to missing values. † Using survey weights to account for complex sample survey design‡ p- value from Chi-squared test

Table 2: Characteristics of NHANES (2009-2012) study population according to periodontal status.*(Continued)

	No Periodontitis(n=1087)			Periodontitis(n=2149)			
Characteristics	**Un-weighted (N)**	**Un-weighted proportion (%)**	**Weighted proportion † (%)**	**Un-weighted (N)**	**Un-weighted proportion (%)**	**Weighted proportion † (%)**	**p-value‡**
ADL							
Eating Difficulty							p=0.60
Yes	51	4.7	4.0	110	5.1	4.2	
No	1036	95.3	96.0	2038	94.9	95.8	
Dressing Difficulty							p=0.07
Yes	122	11.2	9.9	290	13.5	11.4	
No	964	88.8	90.1	1857	86.5	88.6	
Grasping Difficulty							p=0.15
Yes	158	14.5	14.3	354	16.5	16.3	
No	929	85.5	85.7	1795	83.5	83.7	
Lifting Difficulty							p=0.68
Yes	246	22.8	17.3	496	23.5	19.6	
No	831	77.2	82.7	1616	76.5	80.5	
Reaching Difficulty							p=0.70
Yes	192	17.7	14.4	390	18.2	15.4	
No	894	82.3	85.6	1750	81.8	84.6	
Disability							p=0.33
Yes	397	36.5	31.4	823	38.3	34.8	
No	690	63.5	68.6	1326	61.7	65.1	

*Some of the numbers might not add up to the total numbers due to missing values. † Using survey weights to account for complex sample survey design‡ p- value from Chi-squared test

Table3: Characteristics of NHANES (2009-2012) study population according to disability (defined by difficulty in performing any of the following ADL: eating, dressing, grasping, lifting and reaching.*

	Non-disabled(n=2016)			Disabled(n=1220)			
Characteristics	**Un-weighted (N)**	**Un-weighted proportion (%)**	**Weighted proportion † (%)**	**Un-weighted (N)**	**Un-weighted proportion (%)**	**Weighted proportion † (%)**	**p-value‡**
Age							p<0.001
30- 39	129	6.4	7.3	87	7.1	8.1	
40-49	144	7.1	9.0	174	14.3	16.1	
50-59	164	8.1	10.2	231	18.9	22.2	
60-69	918	45.5	46.0	369	30.3	26.1	
70-79	447	22.2	19.0	216	17.7	16.4	
>=80	214	10.6	8.6	143	11.7	11.2	
Sex							p<0.001
Male	1085	53.8	51.7	523	42.9	40.7	
Female	931	46.2	48.3	697	57.1	59.3	
Race							p=0.003
White Non-Hispanic	981	48.7	78.0	531	43.5	66.7	
Black Non-Hispanic	453	22.5	9.1	298	24.4	13.9	
Mexican American	211	10.5	4.0	167	13.7	7.0	
Other Hispanic	200	9.9	3.6	138	11.3	6.3	
Other races including Multi-racial	171	8.5	5.2	86	7.1	6.1	
Education							p<0.001
Less than 9th Grade	209	10.4	5.2	201	16.5	9.4	
9th-11th Grade	288	14.3	10.2	229	18.8	15.6	
High School	461	22.9	22.9	283	23.2	24.8	
Some college	567	28.1	30.9	329	27.0	30.2	
College Graduate	486	24.1	30.7	176	14.4	20.0	
Diabetes status							p<0.001
Diabetes	325	16.1	12.7	331	27.1	23.1	
No Diabetes	1618	80.3	83.7	853	69.9	74.1	
Borderline	72	3.6	3.6	34	2.8	2.7	
Smoking status							p<0.001
Never smokers	1023	50.7	50.5	569	46.6	46.9	
Current smokers	327	16.2	16.5	280	22.9	20.9	
Former smokers	666	33.0	33.0	371	30.4	32.2	

*Some of the numbers might not add up to the total numbers due to missing values. † Using survey weights to account for complex sample survey design‡ p- value from Chi-squared test

Table3: Characteristics of NHANES (2009-2012) study population according to disability (defined by difficulty in performing any of the following ADLs: eating, dressing, grasping, lifting and reaching) (Continued).*

	Non-disabled(n=2016)			Disabled(n=1220)			
Characteristics	**Un-weighted (N)**	**Un-weighted proportion (%)**	**Weighted proportion † (%)**	**Un-weighted (N)**	**Un-weighted proportion (%)**	**Weighted proportion † (%)**	**p-value‡**
Periodontitis							p=0.33
No	690	34.2	42.0	397	32.5	38.3	
Yes	1326	65.8	58.0	823	67.5	61.7	
Periodontitis Severity							p=0.30
No periodontitis	690	34.2	42.0	397	32.5	38.3	
Mild	86	4.3	5.0	64	5.3	6.2	
Moderate	950	47.1	42.2	564	46.2	44.1	
Severe	290	14.4	10.7	195	16.0	11.4	

*Some of the numbers might not add up to the total numbers due to missing values. † Using survey weights to account for complex sample survey design‡ p- value from Chi-squared test

Table 4: The associations of the individual ADL with degrees of periodontitis using multinomial logistic regression

Severity of periodontitis	N (No)	N (Yes)	Unadjusted OR	p-value	Adjusted OR†	p-value
Eating difficulty ADL						
None	1036	51	1.00(Ref)		1.00(Ref)	
Mild	140	10	1.5(0.7-2.9)	0.30	1.2(0.6-2.5)	0.59
Moderate	1442	71	1.0(0.7-1.4)	0.99	0.8(0.5-1.2)	0.31
Severe	456	29	1.3(0.8-2.1)	0.28	0.9(0.5-1.5)	0.68
Dressing difficulty ADL						
None	964	122	1.00(Ref)		1.00(Ref)	
Mild	125	25	1.6(0.9-2.5)	0.05	1.4(0.8-2.2)	0.21
Moderate	1328	184	1.1(0.9-1.4)	0.46	0.9(0.8-1.3)	0.95
Severe	404	81	1.6(1.2-2.1)	<0.01	1.3(0.9-1.8)	0.18
Grasping difficulty ADL						
None	929	158	1.00(Ref)		1.00(Ref)	
Mild	117	33	1.7(1.2-2.5)	0.02	1.6(0.9-2.7)	0.06
Moderate	1238	230	1.1(0.8-1.3)	0.64	1.1(0.8-1.5)	0.48
Severe	394	91	1.4(1.0-1.8)	0.03	1.3(0.9-1.8)	0.18
Lifting difficulty ADL						
None	831	246	1.00(Ref)		1.00(Ref)	
Mild	106	41	1.3(0.9-1.9)	0.18	1.4(0.9-2.0)	0.16
Moderate	1156	335	1.0(0.8-1.2)	0.82	0.9(0.7-1.1)	0.47
Severe	354	120	1.1(0.9-1.5)	0.29	1.1(0.8-1.5)	0.39
Reaching difficulty ADL						
None	894	192	1.00(Ref)		1.00(Ref)	
Mild	118	32	1.3(0.8-1.9)	0.27	1.2(0.8-1.9)	0.44
Moderate	1239	269	1.0(0.8-1.2)	0.92	1.0(0.8-1.2)	0.72
Severe	393	89	1.1(0.8-1.4)	0.71	1.0(0.7-1.3)	0.92

† Adjusted for age, gender, race, education, smoking, diabetes and tooth count

Table 5: The associations of the individual ADL with periodontitis (binary classification) using multivariate logistic regression*

Disability	N (No)	N (Yes)	Unadjusted OR (95% CI)	p-value	OR adjusted for age (95% CI)	p-value	OR: Fully Adjusted* (95% CI)	p-value
No disability			**1.0(Ref)**		**1.0(Ref)**		**1.0(Ref)**	
Any disability	2016	1220	1.1(0.9-1.3)	0.32	1.1(0.9-1.3)	0.20	1.0(0.9-1.2)	0.81
ADL								
No disability			**1.0(Ref)**		**1.0(Ref)**		**1.0(Ref)**	
Eating	3074	161	1.1(0.8-1.5)	0.59	1.1(0.7-1.5)	0.75	0.9(0.6-1.3)	0.47
Dressing	2821	412	1.2(0.9-1.5)	0.06	1.3(1.0-1.6)	0.03	1.1(0.8-1.4)	0.54
Grasping	2724	512	1.2(0.9-1.4)	0.32	1.2(0.9-1.4)	0.16	1.1(0.8-1.9)	0.50
Lifting	2447	742	1.0(0.9-1.2)	0.68	1.1(0.9-1.3)	0.47	1.0(0.8-1.2)	0.96
Reaching	2644	582	1.0(0.9-1.3)	0.70	1.1(0.9-1.3)	0.50	1.0(0.8-1.2)	0.86

* Adjusted for age, gender, race, education, smoking, diabetes and tooth count

Table 6: Prevalence of periodontitis comparing results of our study with the MMWR article*

Severity of periodontitis	Prevalence (Our findings)	Prevalence(MMWR)
	(%)	(%)
Mild	8.8	8.7
Moderate	30.0	30.0
Severe	8.5	8.5

*("Periodontitis Among Adults Aged ≥30 Years — United States, 2009–2010,")

Table7: Baseline study population characteristics and weighed bivariate analysis comparing periodontitis status by selected factors: NHANES 2009-2012 (using Garcia et al., 2014 as reference)*

	Our findings		Article results	
Characteristics	**Periodontitis (N=3873) (%)†**	**No Periodontitis (N=3219) (%)†**	**Periodontitis (N=3871) (%)†**	**No periodontitis (N=3176) (%)†**
Age				
30-34	6.7	16.9	6.6	17.0
35-49	31.0	44.3	31.0	44.5
50-64	37.3	28.5	37.0	28.5
65+	25.0	10.3	25.0	10.0
Gender				
Male	58.6	40.9	58.5	40.9
Female	41.5	58.1	41.5	59.1
Education Level				
Less than High school	23.9	10.2	23.9	10.0
High School	25.4	17.3	25.4	17.2
More than high school	50.7	72.5	50.6	72.8
Marital Status				
Married/Living with partner	65.5	73.0	65.1	73.2
Widowed/Separated	10.3	10.7	10.3	10.7
Never married	24.7	16.3	24.7	16.0
Race				
Non-Hispanic White	61.0	75.5	61.1	75.4
Non-Hispanic Black	13.9	8.1	13.9	8.1
Mexican American	10.8	5.2	10.8	5.3
Other Hispanic	6.4	4.9	6.4	4.9
Other	7.9	6.4	7.9	6.4

Table7: Baseline study population characteristics and weighed bivariate analysis comparing periodontitis status by selected factors: NHANES 2009-2012 (Continued)*

	Our findings		Article results	
Characteristics	**Periodontitis (N=3873) (%)†**	**No Periodontitis (N=3219) (%)†**	**Periodontitis (N=3871) (%)†**	**No periodontitis (N=3176) (%)†**
Smoking				
Yes	53.1	36.0	53.2	35.8
No	46.9	64.0	46.9	64.3

† Using survey weights to account for complex sample survey design. *(Garcia et al., 2014)

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