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Racial Differences in Periodontal Disease and 10-Year Self-Reported Tooth Loss among Late Middle-Aged and Older Adults: The Dental ARIC Study

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Abstract

Objective—To investigate racial differences in the associations between periodontitis and 10-year self-reported incident tooth loss in a biracial, community-based cohort of U.S. late middle-aged and older adults.

Methods—Subjects were 3,466 dentate men and women aged 53–74 who underwent dental examinations from 1996 to 1998. In 2012–2013, telephone interviewers asked participants about tooth loss in the preceding 10 years. Separate multivariable ordinal logistic regression models were used to calculate proportional odds ratios (OR) and 95% confidence intervals (CI) as estimates of association between periodontitis and tooth loss for Whites and African-Americans (AAs).

Results—The majority of participants were White (85%) and female (57%) with 23 teeth on average at enrollment. Approximately half the Whites (56%) and AAs (49%) had periodontitis. At follow-up, approximately 44% of AAs and 38% of Whites reported having lost ≥ 1 tooth. In multivariable models, severe periodontitis (OR = 3.03; 95% CI= 2.42–3.80) and moderate periodontitis (OR = 1.64; 95% CI= 1.39–1.94) were significant risk factors of incident tooth loss among Whites. For AAs, severe but not moderate periodontitis increased the odds of incident tooth loss (OR = 2.22; 95% CI = 1.37–3.59). In the final model, education was inversely associated with incident tooth loss among AAs, while lower income was associated with greater odds of tooth loss among Whites.

Conclusions—In this population-based cohort, there is racial heterogeneity in the association between periodontitis and tooth loss. Interventions to reduce the impact of periodontitis on tooth loss need to consider these differences.

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Human participants protection

No additional human subjects protection approvals were necessary because this study involved the analysis of secondary data that had already been approved for the primary analysis.

Conflict of interest

The authors have no conflicts of interest to report.

Keywords

Tooth loss; Periodontitis; Cohort study; Race; Socioeconomic status

Introduction

Tooth loss has been associated with diminished quality of life and is a risk indicator for chronic systemic conditions such as cardiovascular disease, diabetes, and even mortality in older adults (1–3). While the prevalence of complete tooth loss (edentulism) in the U.S. has decreased in successive generations born after the middle of the 20th century, complete tooth loss affected 24% of Americans aged 65–74 years in 1999–2004. However, the trend of the decline of edentulism and number of missing teeth varied across race and socioeconomic (SES) groups (4). Improving oral health in the elderly has been highly emphasized. *Healthy People 2020* includes a goal to reduce complete tooth loss by 10% (to 21.6 %) among this age group (5). However, there are few models available to target interventions among individuals at high-risk for tooth loss (6–10).

Predictors for tooth loss identified in previous studies include both proximal causes, such as oral pathogenic microorganisms, dental caries and periodontitis, and broader risk indicators, such as self-rated oral health, oral pathogenic micro-organisms, SES, physical and mental health, demographic (2,6–8,10,11), attitudes, and behaviors (such as dental service used and reason for seeking dental treatment) (11–13). Most of these factors were statistically significant, but made small contributions to variation in incident tooth loss. Furthermore, the majority of evidence is from cross-sectional analyses (2,4,14) or prospective cohort studies with a short follow-up period (7,9,11,13,15). To systematically examine the combined influences of biological, social, and behavioral determinants on incident tooth loss, large sample sizes and extended follow-up studies are needed.

Racial disparities in dental diseases, including but not limited to tooth loss, dental caries, and periodontitis in the U.S., have been acknowledged (2,4,5,16). A previous study in older adults identified that significant predictors for tooth loss for Whites were different from African-Americans (AAs). Active caries was a major cause of tooth loss for both races, whereas periodontitis was a predictor only for AAs (7). In addition, a recent study among middle-aged and older adults pointed out that racial disparities in edentulism and tooth loss were partially explained by SES and that the associations were complicated. Compared to Whites, AAs had a higher probability of edentulism; however, when the outcome was adjusted for education and income, AAs had lower odds of edentulism (4). AAs and those of low SES may experience less risk for tooth loss due to the indication that they are less likely to access dental care (11,17).

In the U.S., the prevalence of untreated tooth decay is still high in late middle-aged and older adults (11% and 17%, respectively) and much higher for periodontitis for (53% and 68%, respectively) (18). SES factors associated with periodontal disease progression and tooth loss have been reported (15,17). However, there was limited evidence to suggest that the influence of periodontal disease on tooth loss in the elderly differs with regard to race and SES (i.e, education and income) (17). In addition, the classification developed by the

Centers for Disease Control and Prevention (CDC) and the American Academy of Periodontology (AAP) is designed to provide as standard case definitions for population-based surveillance (18,19). Its use in predicting incident tooth loss has yet to be reported.

This study investigated whether racial differences exist in the association between periodontal disease and self-reported incident tooth loss, and explored the influence of SES on racial variations in the associations between periodontitis and tooth loss among late middle-aged and older adults in the Atherosclerosis Risk in Communities (ARIC) and Dental ARIC studies.

Methods

Design and study population

This analysis was based on existing data from ARIC and Dental ARIC studies. Sampling and data collection procedures used in ARIC and its ancillary studies have been described elsewhere (20,21). Briefly, the ARIC study is a prospective investigation of the etiology and natural history of atherosclerosis and clinical cardiovascular disease of middle-aged adults (15,792 individuals aged 45–64 at inception) enrolled between 1987–1989 (Visit 1) via probability sampling in a biracial cohort from four U.S. communities (Forsyth County, NC; Washington County, MD; suburban Minneapolis, MN; and Jackson, MS) Participants from Washington County and Minneapolis were almost exclusively Whites, whereas the Jackson sample consisted solely of AAs. The Forsyth included AAs and Whites. (20). The first 4 visits were conducted at approximately three-year intervals; the last completed exam visits occurred during the period 2011–2013 (Visit 5). Annual follow-up of the cohort by telephone began in 1987 to maintain contact and to assess the health status of the cohort. Beginning in 2012, the cohort was contacted semi-annually. Dental ARIC, an ancillary study of the ARIC, was conducted at Visit 4 (1996–1998). Data collection included a comprehensive dental examination, the collection of gingival crevicular fluid (GCF), dental plaque, and serum, and an interview. Study participants requiring antibiotic prophylaxis for periodontal probing were excluded from the Dental ARIC study. At Visit 4, of the 11,337 participants completing a dental screening questionnaire, approximately 14% (n = 1,590) reported complete tooth loss. Among 9,726 dentate participants, 68.6% (n = 6,676) received comprehensive dental examinations.

For the purpose of this analysis, eligible subjects were dentate people who received dental examinations at Visit 4, and participated in semi-annual follow-up interviews in 2012–2013. Of 6,676 dentate participants, there were 4,034 study subjects (60.4%) eligible for the analysis.

Baseline dental examination and interview in 1996–1998 (Visit 4)

At Visit 4, participants who were enrolled in the Dental ARIC study answered the structured questionnaires and underwent dental examinations. During the dental examination, the number of teeth present, root fragments, decayed surfaces, and filled surfaces were recorded for all teeth, including third molars. Coronal caries was recorded using criteria described by Radike. If less than ¼ of the crown was retained, it was recorded as a root fragment. Root caries was recorded as present if there was a discrete, well-defined, and discolored cavitation on the root surface and the explorer entered easily. Individuals received periodontal probing depth (PPD) and gingival recession (GR) assessments at six sites per tooth on all teeth with a UNC-15 periodontal probe by four trained dental hygienists. Examiners were calibrated to a standard examiner, and percent agreement of clinical attachment level within 1 mm between these examiners and the standard examiner ranged from 83.2% to 90.2%. Intra-class correlation coefficients ranged from 0.76 to 0.90, indicating excellent to outstanding agreement and weighted kappa statistics ranged from 0.76 to 0.86, indicating excellent agreement (21). The clinical attachment level (CAL) was calculated from the sum of PPD and GR scores. Periodontal disease prevalence at baseline was derived according to CDC/AAP periodontal disease case classification (22). Moderate periodontitis was defined as ≥ 2 interproximal sites with CAL ≥ 4 mm (not on the same tooth) or ≥ 2 interproximal sites with PPD ≥ 5 mm (not on the same tooth). Severe periodontitis was defined as ≥ 2 interproximal sites with CAL ≥ 6 mm (not on the same tooth) and ≥ 1 interproximal site with PPD ≥ 5 mm (not on the same tooth).

The following variables obtained from answers to a self-reported questionnaire and dental examination were considered as potential covariates in the analysis based on the behavioral model of health services utilization proposed by Andersen (23). Predictors for tooth loss were traditionally grouped as predisposing, enabling, and need factors (11,14,23). Predisposing characteristics, e.g. race, gender, education, dental attitudes, oral health behaviors, and health status, were either non-modifiable or modifiable and exist prior to disease. In this study, we defined race, gender, and education as non-modifiable social characteristics, while oral health behaviors (i.e. tooth brushing, dental flossing, a reason for dental visit), smoking, diabetes were grouped as modifiable health behaviors and health status. Race was classified as AA or White. Participants' education was grouped as less than high school (< 12 years), completion of high school (12–16 years), or advanced (≥ 17 years). Frequency of tooth brushing was dichotomized as not at all or one time vs. two or more times in the preceding day. Frequency of dental flossing was categorized as not at all, one time, or two or more times in the preceding week. The reason for dental visits was dichotomized as on a regular basis vs. problem-oriented. Diabetic status was determined by fasting plasma glucose ≥ 126 mg/dL, non-fasting plasma glucose ≥ 200 mg/dL, self-reported history of physician-diagnosed diabetes, or current medication for diabetes. Smoking was coded as current, former, and never. Enabling characteristics are factors that affect one's ability to access the health care system, such as income. In this study, annual household income was used as an indicator for financial ability to use dental care. Household income was coded as < $25,000, $25,000–$50,000, >$50,000, or not reported. Need variables indicated dental conditions or disease levels that were regarded as proximal contributors to incident tooth loss. In this analysis, baseline dental conditions were periodontal disease, number of remaining teeth, root fragment, root caries, and coronal caries. Periodontal disease was classified as severe, moderate, and none/mild as previously described. The number of remaining teeth was grouped as ≥20 teeth, 10–19 teeth, and 1–9 teeth. Root fragment, coronal caries and root caries were dichotomized as present or absent.

Telephone interview at 2012–2013 semi-annual follow-up

The outcome measure was self-reported tooth loss in the 10 years preceding the 2012–2013 semi-annual telephone interview. Participants were asked at the follow-up call to assess tooth loss in the previous ten years: "Have you lost any teeth in the past ten years?" The answers were categorized as none, one or two, three or more, and don't know. In this study, we did not validate participants' responses to the question. Therefore, we excluded from the analyses participants (n = 40) who responded to the question with don't know.

Statistical methods

All analyses were performed using SAS 9.3 (Cary, NC, USA) and STATA 13.0 (Stata Corp., College Station, TX, USA). We primarily used a complete case analysis for the outcome variable and assessed the frequency and pattern of missing independent variables. For the purpose of the analysis, after excluding those with missing covariates and those who did not report household income (n = 748), the final analytic samples included 3,466 subjects. Descriptive statistics were used to evaluate the distribution of the categorical and continuous independent variables. Bivariate analyses (Chi-square test and one-way ANOVA) were used to evaluate the race-specific baseline characteristics and the associations of covariate variables at the time of the dental exam with the 10-year incidence categorized as loss of none, one or two, and three or more teeth within race strata. Characteristics between people retained and those lost to follow-up were compared.

The model building strategy included a literature review and the Andersen behavioral model (7,11,13,23). Those variables that were available in the Dental ARIC dataset together with the results from bivariate analyses of covariates for incident tooth loss were considered in the multivariable analysis. We used a multivariable ordinal logistic regression model to investigate the association between periodontal disease and three categories of self-reported incident tooth loss. Parameter estimates were converted to odds ratios with 95% confidence intervals (CI). For each racial group, crude associations of periodontal disease and each covariate with self-reported tooth loss outcome were estimated. To justify the use of separate models for Whites and AAs, we evaluated a combined-race model that tested the main effect of periodontal disease, covariates, and the interaction of each covariate with race, controlling for other variables. A criterion of p-value <0.20 was used to determine effect heterogeneity by race. Interaction terms of eight variables with race (periodontal disease, number of remaining teeth, root fragments, coronal caries, root caries, education, diabetes, and flossing) were statistically significant. We, therefore, developed separate final models to investigate the associations of periodontal disease with the risk of losing teeth for Whites and AAs. We began with a full model controlling for baseline clinical conditions, financial ability to use dental care as indicated by household income variable, non-modifiable social characteristics and modifiable health behaviors and health status. To derive parsimonious final models, we used a backward stepwise variable selection method. A criterion of p-value > 0.10 was used for a variable to be removed and p-value <0.05 for a variable to be entered in the model.

Results

The characteristics of the study samples are presented in Table 1. Of the 3,466 study subjects with complete data, 85% were Whites and 57% were female, with an average age of 61.3 ± 5.3 years at Visit 4. Compared to study participants with complete data, those lost to follow-up or with missing data were on average older, more likely male and more likely AAs. They also were more likely to have less education, lower household income, more medical conditions, and poor oral health (Supplemental table 1).

Table 1 presents overall all and race-specific baseline characteristics. AAs were slightly younger than Whites at baseline. Overall, a higher proportion of AAs had attained less than a high school education, low household income, diabetes, a lower frequency of self-reported tooth brushing and flossing, and irregular use of dental services, compared to Whites. Current and past smokers accounted for 54% of all subjects, with a greater percentage of Whites than AAs. Subjects had an average of 22.8 ± 6.6 remaining natural teeth with an average of 0.04 ± 0.3 root fragments, 0.4 ± 1.4 decayed and 18.2 ± 12.7 filled coronal surfaces, and 0.1 ± 0.6 decayed and 0.7 ± 1.5 filled root surfaces (data not shown in Table). Racial differences were significant for all baseline dental conditions: number of teeth, root fragment, coronal caries, root caries, and periodontal disease. Greater than 80% of Whites had retained ≥ 20 teeth, while only half of AAs had retained ≥ 20 teeth. The overall prevalence of root fragments, untreated coronal caries, root caries, and severe periodontitis was approximately 3%, 15%, 5%, and 15%, respectively, with a higher prevalence among AAs compared to Whites. In contrast, Whites had a greater proportion of filled coronal and root surfaces than AAs (data not shown in Table).

Table 2 presents the results of baseline characteristics and self-reported incident tooth loss stratified by race. Over one-third (39%) of study participants reported the loss of at least one tooth during the 10-year period. Approximately 44% of AAs lost at least one tooth versus 38% of white subjects. In addition, tooth loss ≥ 3 was found to be more than twice as high among AAs compared to white participants (27% vs. 12%).

Tooth loss incidence was not significantly different between age groups for both races, while some factors, e.g., gender, diabetes, and smoking, were significantly associated with self-reported tooth loss only among Whites. White men were more likely to report greater tooth loss (≥ 3 teeth) than white women (16% vs. 10%), whereas tooth loss among AAs was similar for both men and women (30% vs. 26%). Tooth loss of 1–2 teeth was slightly different for both diabetic and non-diabetic participants among AAs (18% vs. 16%) and Whites (21% vs. 26%), while tooth loss of more than 3 teeth was more frequently reported by AA than white participants with diabetes (36% vs. 16%). Both AA and Whites who lost many teeth tended to report that they were current smokers. However, greater tooth loss (≥ 3) was similar for former and nonsmoking participants among AAs (27% vs. 24%, respectively). Among nonsmoking participants, greater tooth loss was also more frequently reported by AAs than Whites (24% vs. 9%).

For both races, tooth loss was significantly different between educational levels and income. About half of participants with basic education lost at least one tooth during the follow-up, while about one third of participants with advanced education experienced tooth loss for both AAs and Whites. Compared to participants with high income, those with low income were more likely to have experienced more tooth loss. However, AAs tended to report loss of more teeth (≥ 3 teeth) than Whites across household income groups.

In bivariate analyses, oral health behaviors and baseline clinical measures of oral health differed significantly according to levels of incident tooth loss in both racial groups. Tooth loss was associated with infrequent tooth brushing, infrequent tooth flossing, and infrequent or symptomatic dental visits for both racial groups. However, AAs with infrequent tooth brushing or flossing were more likely to report loss ≥ 3 teeth compared to Whites (35%, 36% vs. 16%, 16%, respectively).

For both AAs and Whites, individuals who lost ≥3 teeth were more likely to have had fewer teeth at baseline. In addition, while 27%, 41%, and 37% of white subjects with 1–9, 10–19, and ≥ 20 remaining teeth, respectively, had lost at least one tooth, almost half of AAs had lost at least one tooth across the category of remaining teeth. Tooth loss incidence was associated with greater numbers of retained root, root caries, and coronal caries in both racial groups. White participants who had root fragments reported the loss of at least one tooth more frequently than AAs (58% vs.41%). AAs who had root caries were more likely to report loss of at least one tooth than Whites (57% vs. 48%), while percentages of subjects with coronal caries who had lost at least one tooth among Whites and AAs were slightly different (46% vs.49%). More than half of AA and white participants with severe periodontitis had lost at least one tooth, whereas less than one third (28%) of Whites with none or mild periodontitis compared to 39% of AAs had lost at least one tooth.

Findings from the race-specific unadjusted and multivariable analyses are presented in Table 3. In the final model, compared to none or mild periodontitis, Whites with severe periodontitis and moderate periodontitis had 3.03 times (OR =3.03, 95% CI = 2.42–3.80) and 1.64 times (OR =1.64, 95% CI = 1.39–1.94) the odds of tooth loss, respectively. AAs with severe periodontitis had double odds (OR = 2.22, 95% CI = 1.37–3.59) for tooth loss; however, a significant difference was not observed for those with moderate periodontitis.

In the final models, the set of significant covariates for self-reported tooth loss differed between AAs and Whites. For Whites, significant covariates for tooth loss included the number of remaining teeth, root fragments, gender, household income, smoking and reason to visit a dentist. Covariates that were significantly associated with incident tooth loss for AAs were root caries, education, diabetes and reason to visit a dentist. No significant association between oral health behaviors (i.e., tooth brushing and flossing) with self-reported tooth loss was observed in either race. Reason to visit a dentist was an independent predictor for tooth loss in both racial groups, even after adjustment for other predictors. In the final models, odds of tooth loss was 35% greater in white participants (OR = 1.35, 95% CI = 1.07–1.69) and 61% greater in AA participants (OR =1.61, 95% CI = 1.10–2.38) who had irregular dental visit compared to those visited a dentist on regular basis. Low level of education exhibited a strong significant association with increased odds of tooth loss among AAs, but not among Whites in the multivariable analyses. In contrast, lower household income was associated with greater odds of tooth loss among Whites, while there was little difference across household income levels. There were no significant associations observed with the level of income among AAs in the final model.

Discussion

At baseline, dentate AAs had fewer teeth, but higher prevalence of dental diseases compared to their White counterparts. As expected, a higher proportion of AAs continued to lose more teeth than Whites. In this cohort, periodontal disease exhibited stronger association with tooth loss among Whites compared to AAs. However, the different set of significant covariates in the final multivariable adjusted models between AAs and Whites, suggested effects heterogeneity for contributing factors, including income and education, to incident tooth loss between sub-populations.

The most important strengths of the present study are the use of data from the large population-based cohort of community-dwelling, late middle-aged and older adults in the U.S. Aside from providing information about etiologic mechanisms in tooth loss, the analyses identify the types of Dental ARIC participants who are most likely to experience tooth loss. Also, based on a full-mouth examination protocol, this assessment, this is the first study of tooth loss incidence to use the CDC/AAP classification of periodontitis as a predictor of tooth loss. The contribution of periodontal disease to tooth loss may depend on the exposure definitions of periodontitis. Case definitions for periodontal diseases are crucial as they affect the internal and external validity of the study, estimation of periodontal treatment needs as well as comparisons among the epidemiologic studies (19). A study that compared several definitions of periodontal disease for predicting 5-year tooth loss events suggested that prediction models need to be gender- and age-specific, while mean CAL was the best definition to assess incident tooth loss. However, tooth loss and periodontal assessment in that study were restricted to half-mouth examinations (6).

A number of potential limitations of this study should be acknowledged. First, the study participants included in the analysis were healthier and had higher SES than non-participants at baseline dental examination. Prevalence of severe periodontal disease was greater among non-participants than participants (20% vs.15%). These differences raised concerns about selection bias and thus the observed effects of periodontal disease on self-reported tooth loss may be lower than the true population parameter. Second, the reliability of interview data was not assessed. However, many studies (24,25) have found high agreement between the clinically recorded and the self-reported number of teeth. Consequently, it is unlikely that the self-reported tooth loss has biased the results. Lastly, the generalizability of the results only extends to the four geographic areas that were sampled.

Several epidemiologic studies have reported tooth loss incidence in the elderly, each with different periods of follow-up and outcome measures (7,9,26–28). Previous prospective studies had either smaller samples with high attrition rates at follow-up (7,13,27) or shorter follow-up periods (9,13,15,26). The study in elderly Iowans that had a similar follow-up period reported that maximum periodontal attachment loss per person was the only predictor significantly associated with the occurrence of tooth loss after adjusting for other baseline characteristics. In the present study, no single dental condition emerged as a dominant risk factor for tooth loss, but severe periodontal disease was the only underlying clinical condition consistently associated with tooth loss in both racial groups. The Iowa study reported a higher incidence (~62%) of tooth loss than the present study (~39%). Such a result may be due to participants who were generally older at baseline (≥ 65 years) (27).

A high burden of periodontal disease in the U.S. has been previously reported (29). Severe periodontitis prevalence (CDC/AAP case definition) estimated in 2009–2012 surveys in the U.S. was 8.9%, representing approximately 5.8 million people (29). In our study samples, severe periodontitis prevalence at baseline (1996–1998) was greater (14.9%) and more than half of the participants with severe periodontitis (55.8%) reported tooth loss at least once in the previous ten years. However, since the study investigated the association between periodontitis and incident tooth loss, the higher prevalence is not really a limitation. Nonetheless, these findings demonstrate there is a need for effective periodontal disease prevention as the accumulative loss of teeth over a lifetime may affect the well-being of older adults (1,3).

Drake et. al (1995) reported that predictors for tooth loss among Whites differed from AAs in the Piedmont 65+ Dental Study. In that study, untreated caries was a major cause of tooth loss in both racial groups, while periodontal disease was a risk predictor only for AAs (7). Contrary to previous findings, in this multivariable analysis, untreated coronal caries was not associated with tooth loss in either race. The associations between other baseline dental conditions, i.e., number of remaining teeth, root fragments, root caries, and periodontal disease, were different by race. Interestingly, we observed a stronger association between periodontal disease and incident tooth loss among Whites than AAs. These results suggest the limits of generalization of tooth loss findings across different populations and that there may be different important predictors for tooth loss.

The possible sources of the difference in the magnitude of the association between periodontal disease and incident tooth loss by race may be due to the multifactorial etiology of tooth loss, a residual confounding from number of remaining teeth, smoking, and SES, or an unmeasured confounding in this study, e.g., attitudes toward oral health care and dental service use. Tooth loss is a result of many factors and their interactions involving clinical conditions, clinicians' judgments, insurance coverage, patients' medical health, and patients' behaviors (9,12,13,27,30). Our data are consistent with previous reports. Results reported in Table 3 suggest an important role for baseline dental disease or need variables in predictive tooth loss. Our results also underscore the importance of dental attendance patterns (i.e., reason to visit a dentist) for tooth loss. Although the effect size was modest, the reason to visit a dentist was the only modifiable health behavioral factor that was significantly associated with tooth loss in both races. Individuals who were problem-oriented attenders and had negative attitudes toward dental care were more likely to receive dental extractions (13). Current smokers were also at greater risk of losing teeth in the bivariate analyses which is in agreement with results from previous investigations (9,28). However, in the final model, the effect of cigarette smoking on tooth loss is attenuated and non-significant for AAs. This may be because smoking is a major risk factor for periodontal disease; thus, smoking, like diabetes, became less significant in multivariable models (9). Also, it this present study, our self-reported measure of smoking status classified as former, current, and never smokers may not adequately reflect the full extent of the influence of smoking. More detailed measures of smoking (e.g., number of cigarettes, smoking duration, cotinine levels) might have better captured the influence of smoking on incident tooth loss. It is worth noting that this study did not differentiate tooth loss by cause. In addition, it is impossible to assess all possible influences on tooth loss in this study. Factors such as physical disabilities, drug-related anticholinergic burdens, and cognitive impairment have been reported in previous studies as factors associated with tooth loss in older adults (8,10). These factors may play different roles contributing to varying degrees to tooth loss risk in older people. In this study, however, we did not consider these parameters.

As mentioned previously, tooth loss is a complex outcome that is influenced directly by oral diseases or indirectly by social inequalities. A previous study has illustrated the mechanism of the social disparities in tooth loss (11). Race and SES were important determinants of different dental disease levels before entering the dental care system and influenced differences in dental services received after dental visits. Specifically, AAs and low SES had more dental symptoms, but were less likely to access dental care. Once they received dental care, they had significantly higher odds of tooth loss. Another study has confirmed that dental care utilization was the only factor that consistently associated with tooth loss across racial groups (17). In the present study, the incidence of tooth loss was greater in low SES groups as defined by income and education. This finding is in agreement with previous studies that highlighted low income as a contributing factor for tooth loss and complete tooth loss (4,13,15). However, our data suggest that the influences of income and education on incident tooth loss differ by race. The results of the current study are in line with a previous study that showed the disparities in dental health due to SES factors are not shared equally across racial groups. Furthermore, there was a weaker association between SES with tooth loss for AAs than Whites (17). Findings in our analyses are in partially in agreement with the previous reports. Less education was associated with higher probabilities of tooth loss among AAs versus Whites. In contrast, lower household income was associated with higher probabilities of tooth loss among Whites versus AAs. At baseline, although prevalence of moderate and severe periodontal disease was slightly different between Whites and AAs, Whites had more retained teeth than AAs, with a greater chance to be affected by periodontal problems. Moreover, white participants were more likely to visit a dentist on a regular basis (86%) compared to AAs (38%). Thus, it is possible that the greater odds for tooth loss due to periodontal disease among Whites is a result of more opportunities to access dental care, though extraction may be the treatment of choice for teeth affected by severe periodontitis. Older adults may have limited financial resources to support costly dental treatment and tooth retention. This result should be interpreted with caution as information regarding dental insurance and dental visits was unavailable. In addition, we adjusted for the number of teeth, reason to visit a dentist, household income, education, though residual confounding from these factors cannot be eliminated.

As older adults tend to retain more natural teeth, and these teeth are at increased risk for caries and periodontal disease. Identifying interventions and public health programs to assist the elderly maintain a healthy dentition is a challenging but important task. Additional longitudinal studies in diverse populations are needed to better characterize factors contributing to incident tooth loss. Furthermore, collection of dental utilization data and reason for tooth loss may also serve to more fully clarify the complex associations between periodontal disease and tooth loss as well as the mechanism of SES influence in diverse racial groups.

Conclusion

Greater severity of periodontal disease is significantly associated with an increased risk for tooth loss. However, the magnitudes of the associations were not similar for Whites and AAs. The associations of education, income, and other predictors with tooth loss vary across racial groups. Interventions and public health programs need to consider these differences when attempting to reduce burden of periodontal disease on tooth loss in later life.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Table 1

Baseline characteristics of the Dental ARIC follow-up cohort, overall and stratified by race

Baseline characteristics (n, col%)	**All (n =3466)**	**Whites (n =2959)**	**African-Americans (n =507)**	***P-value***
Male	1496 (43.2)	1318 (44.5)	178 (35.1)	<0.001
Age at baseline (years)				
51–59	1481 (42.7)	1191 (40.3)	290 (57.2)	<0.001
60–65	990 (28.6)	871 (29.4)	119 (23.5)	
> 65	995 (28.7)	897 (30.3)	98 (19.3)	
Educational attainment				
Less than high school	342 (9.9)	229 (7.7)	113 (22.3)	<0.001
Completion of high school	1542 (44.5)	1386 (46.9)	156 (30.8)	
Postsecondary education	1582 (45.6)	1344 (45.4)	238 (46.9)	
Household income (1996–1998 US dollars)				
<$25,000	675 (19.5)	437 (14.8)	238 (47.0)	<0.001
$25–<50,000	1245 (35.9)	1104 (37.3)	141 (27.8)	
$50,000 or more	1546 (44.6)	1418 (47.9)	128 (25.2)	
Smoking				
Current	364 (10.5)	301 (10.2)	63 (12.4)	0.001
Former	1500 (43.3)	1318 (44.5)	182 (35.9)	
Never	1602 (46.2)	1340 (45.3)	262 (51.7)	
Diabetes	402 (11.6)	311 (10.5)	91 (18.0)	<0.001
Dental flossing				
Not at all	1123 (32.4)	876 (29.6)	247 (48.7)	<0.001
One time per week	304 (8.8)	257 (8.7)	47 (9.3)	
Two times per week or more	2039 (58.8)	1826 (61.7)	213 (42.0)	
Brushing teeth once daily or none	996 (28.7)	832 (28.1)	164 (32.3)	0.052
Problem-oriented dental visit	742 (21.4)	427 (14.4)	315 (62.1)	<0.001
Number of remaining teeth				
1–9 teeth	275 (7.9)	179 (6.1)	96 (18.9)	<0.001
10–19 teeth	509 (14.7)	350 (11.8)	159 (31.4)	
≥20 teeth	2682 (77.4)	2430 (82.1)	252 (49.7)	
Root fragments	89 (2.6)	48 (1.6)	41 (8.1)	<0.001
Coronal caries	523 (15.1)	294 (9.9)	229 (45.2)	<0.001
Root caries	187 (5.4)	104 (3.5)	83 (16.4)	<0.001
Periodontal disease				
None/mild	1556 (44.9)	1301 (44.0)	255 (50.3)	<0.001
Moderate	1394 (40.2)	1232 (41.6)	162 (32.0)	
Severe	516 (14.9)	426 (14.4)	90 (17.7)	

Table 2

Baseline characteristics and 10-year self-reported tooth loss by race

Baseline characteristics (n, row%)	White (n=2959)				African-American (n=507)			
	None (n=1842)	1–2 teeth (n=750)	≥ 3 teeth (n=367)	*P-value*	None (n=286)	1–2 teeth (n=83)	≥3 teeth (n=138)	*P-value*
Gender								
Male	781 (59.3)	326 (24.7)	211 (16.0)	<0.001	95 (53.4)	29 (16.3)	54 (30.3)	0.489
Female	1061 (64.7)	424 (25.8)	156 (9.5)		191 (58.1)	54 (16.4)	84 (25.5)	
Age at baseline (years)								
51–59	753 (63.2)	291 (24.4)	147 (12.3)	0.063	157 (54.1)	56 (19.3)	77 (26.6)	0.349
60–65	563 (64.6)	215 (24.7)	93 (10.7)		72 (60.5)	14 (11.8)	33 (27.7)	
> 65	526 (58.6)	244 (27.2)	127 (14.2)		57 (58.1)	13 (13.3)	28 (28.6)	
Educational attainment								
Less than high school	124 (54.2)	58 (25.3)	47 (20.5)	<0.001	45 (39.8)	17 (15.1)	51 (45.1)	<0.001
Completion of high school	856 (61.7)	346 (25.0)	184 (13.3)		94 (60.3)	18 (11.5)	44 (28.2)	
Postsecondary education	862 (64.2)	346 (25.7)	136 (10.1)		147 (61.8)	48 (20.2)	43 (18.0)	
Household income (1996–1998 US dollars)								
<$25,000	255 (58.3)	113 (25.9)	69 (15.8)	<0.001	123 (51.7)	33 (13.9)	82 (34.4)	0.001
$25–<50,000	642 (58.1)	288 (26.1)	174 (15.8)		86 (61.0)	19 (13.5)	36 (25.5)	
$50,000 or more	945 (66.7)	349 (24.6)	124 (8.7)		77 (60.2)	31 (24.2)	20 (15.6)	
Smoking								
Current	164 (54.5)	79 (26.2)	58 (19.3)	<0.001	34 (54.0)	4 (6.3)	25 (39.7)	0.054
Former	797 (60.4)	337 (25.6)	184 (14.0)		99 (54.4)	34 (18.7)	49 (26.9)	
Never	881 (65.8)	334 (24.9)	125 (9.3)		153 (58.4)	45 (17.2)	64 (24.4)	
Diabetes								
No	1648 (62.3)	684 (25.8)	316 (11.9)	0.033	244 (58.7)	67 (16.1)	105 (25.2)	0.064
Yes	194 (62.4)	66 (21.2)	51 (16.4)		42 (46.1)	16 (17.6)	33 (36.3)	
Dental flossing								
Not at all	509 (58.1)	226 (25.8)	141 (16.1)	<0.001	127 (51.4)	34 (13.8)	86 (34.8)	0.005
One time per week	156 (60.7)	65 (25.3)	36 (14.0)		31 (66.0)	8 (17.0)	8 (17.0)	
Two times per week or more	1177 (64.5)	459 (25.1)	190 (10.4)		128 (60.1)	41 (19.2)	44 (20.7)	
Tooth brushing								

Baseline characteristics (n, row%)	White (n=2959)				African-American (n=507)			
	None (n=1842)	1–2 teeth (n=750)	≥ 3 teeth (n=367)	*P-value*	None (n=286)	1–2 teeth (n=83)	≥3 teeth (n=138)	*P-value*
Once daily or none	492 (59.1)	204 (24.9)	133 (16.0)	0.001	88 (53.6)	17 (10.4)	59 (36.0)	0.002
At least twice daily	1350 (63.5)	543 (25.5)	234 (11.0)		198 (57.7)	66 (19.2)	79 (23.1)	
Reasons to visit a dentist								
Problem-oriented	233 (54.6)	101 (23.6)	93 (21.8)	<0.001	158 (50.2)	52 (16.5)	105 (33.3)	<0.001
Regular basis	1609 (63.6)	649 (25.6)	274 (10.8)		128 (66.7)	31 (16.1)	33 (17.2)	
Number of remaining teeth								
1–9 teeth	130 (72.6)	25 (14.0)	24 (13.4)	<0.001	55 (57.3)	11 (14.5)	30 (31.3)	<0.001
10–19 teeth	205 (58.6)	64 (18.3)	81 (23.1)		87 (54.7)	14 (8.8)	58 (36.5)	
≥20 teeth	1507 (62.0)	661 (27.2)	262 (10.8)		144 (57.1)	58 (23.0)	50 (19.9)	
Root fragments								
No	1822 (62.6)	743 (25.5)	349 (11.9)	<0.001	262 (56.2)	82 (17.6)	122 (26.2)	0.022
Yes	20 (41.7)	7 (14.6)	21 (43.7)		24 (58.5)	1 (2.4)	16 (39.1)	
Coronal caries								
No	1683 (63.1)	681 (25.6)	301 (11.3)	<0.001	170 (61.1)	53 (19.1)	55 (19.8)	<0.001
Yes	159 (54.1)	69 (23.5)	66 (22.4)		116 (50.7)	30 (13.1)	83 (36.2)	
Root caries								
No	1788 (62.6)	729 (25.5)	338 (11.9)	<0.001	250 (59.0)	76 (17.9)	98 (23.1)	<0.001
Yes	54 (51.9)	21 (20.2)	29 (27.9)		36 (43.4)	7 (8.4)	40 (48.2)	
Periodontal disease								
None/mild	931 (71.6)	279 (21.4)	91 (7.0)	<0.001	156 (61.2)	44 (17.2)	55 (21.6)	0.003
Moderate	722 (58.6)	345 (28.0)	165 (13.4)		90 (55.5)	28 (17.3)	44 (27.2)	
Severe	189 (44.4)	126 (29.6)	111 (26.0)		40 (44.5)	11 (12.2)	39 (43.3)	

Table 3

Unadjusted and adjusted proportional odds ratios (OR) and 95% confidence intervals (CI)* for 10-year self-reported tooth loss

	White (n=2959)			African-American (n=507)		
Baseline characteristics	**Unadjusted**	**Full model**	**Final model**	**Unadjusted**	**Full model**	**Final model**
Periodontal disease						
Moderate vs. None/Mild	1.80 (1.53–2.11)	1.63 (1.38–1.93)	1.64 (1.39–1.94)	1.28 (0.87–1.88)	1.14 (0.75–1.74)	1.21 (0.81–1.79)
Severe vs. None/Mild	3.49 (2.81–4.34)	2.96 (2.35–3.72)	3.03 (2.42–3.80)	2.28 (1.43–3.64)	2.14 (1.28–3.59)	2.22 (1.37–3.59)
Number of remaining teeth						
10–19 teeth vs. 1–9 teeth	2.03 (1.38–3.00)	2.27 (1.51–3.42)	2.23 (1.49–3.35)	1.18 (0.72–1.95)	1.39 (0.81–2.39)	
≥20 teeth vs. 1–9 teeth	1.47 (1.05–2.06)	2.19 (1.52–3.17)	2.09 (1.46–3.01)	0.84 (0.53–1.32)	1.22 (0.72–2.08)	
Root fragments vs. None	3.69 (2.09–6.53)	2.90 (1.60–5.25)	2.93 (1.63–5.26)	1.18 (0.62–2.26)	0.62 (0.30–1.29)	
Coronal caries vs. None	1.63 (1.29–2.07)	1.12 (0.86–1.46)		1.76 (1.25–2.47)	1.17 (0.77–1.76)	
Root caries vs. None	1.89 (1.28–2.78)	1.05 (0.69–1.59)		2.39 (1.50–3.79)	1.89 (1.12–3.19)	1.86 (1.14–3.03)
Household income (1996–1998 US dollars)						
<$25,000 vs. $50,000 or more	1.50 (1.21–1.56)	1.42 (1.11–1.80)	1.50 (1.19–1.89)	1.70 (1.12–2.58)	1.06 (0.62–1.81)	
$25–<50,000 vs. $50,000 or more	1.51 (1.29–1.77)	1.44 (1.22–1.70)	1.47 (1.25–1.73)	1.13 (0.71–1.81)	1.05 (0.63–1.76)	
Educational attainment						
Less than high school vs. Advanced	1.66 (1.26–2.18)	1.20 (0.88–1.63)		2.82 (1.83–4.35)	2.06 (1.23–3.46)	2.15 (1.36–3.41)
Completion of high school vs. Advanced	1.14 (0.98–1.33)	1.06 (0.90–1.24)		1.22 (0.82–1.83)	1.00 (0.64–1.57)	1.02 (0.67–1.54)
Smoking						
Current vs. Never	1.73 (1.35–2.21)	1.37 (1.06–1.77)	1.37 (1.06–1.77)	1.48 (0.86–2.55)	1.12 (0.62–2.02)	
Former vs. Never	1.30 (1.11–1.51)	1.13 (0.96–1.33)	1.13 (0.96–1.33)	1.16 (0.81–1.67)	1.14 (0.77–1.69)	
Diabetes vs. None	1.07 (0.84–1.35)	0.98 (0.75–1.23)		1.67 (1.08–2.56)	1.44 (0.91–2.27)	1.51 (0.96–2.37)
Dental flossing						
Not at all vs. Two times per week or more	1.36 (1.16–1.60)	1.14 (0.96–1.37)		1.60 (1.12–2.29)	0.55 (0.28–1.11)	
One time vs. Two times per week or more	1.21 (0.93–1.57)	1.11 (0.85–1.46)		0.79 (0.41–1.50)	0.98 (0.63–1.51)	
Brushing teeth once daily or none vs. At least twice daily	1.26 (1.07–.148)	1.04 (0.88–1.24)		1.39 (0.97–2.00)	1.06 (0.70–1.60)	
Problem-oriented vs. Regular dental visit	1.62 (1.33–1.99)	1.24 (0.98–1.57)	1.35 (1.07–1.69)	2.09 (1.46–3.00)	1.66 (1.05–2.60)	1.61 (1.10–2.38)
Male vs. Female	1.17 (0.92–1.50)	1.12 (0.95–1.33)	1.17 (1.00–1.37)	1.23 (0.86–1.75)	1.10 (0.71–1.70)	

[*] Separate multivariate ordinal logistic regression models for Whites and AAs estimated the associations between periodontal disease and the proportional odds of losing teeth. In the final model for Whites, significant covariates included in the model were the number of remaining teeth, root fragments, household income, smoking, reason to visit a dentist and gender. While, covariates that were significantly associated with incident tooth loss for AAs were root caries, education, diabetes and reason to visit a dentist.