Published in final edited form as:

Spec Care Dentist. 2012 ; 32(6): 234–241. doi:10.1111/j.1754-4505.2012.00280.x.

Prevalence of oral health problems in U.S. adults, NHANES 1999–2004: exploring differences by age, education, and race/ethnicity

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Abstract

Using the National Health and Nutrition Examination Surveys (NHANES) 1999–2004, the authors examined age patterns in oral health indicators by race/ethnicity and socioeconomic status related to edentulism, presence of root caries, and periodontal disease. Our analysis included subjects who were non-Hispanic White, Mexican American, and African American over the age of 20, and who participated in the NHANES oral health examination. African Americans experienced more oral health problems at younger ages; as age increased, so did racial disparities in oral health problems. Lower educational attainment was strongly associated with more oral health problems at all ages.

These results may indicate a faster progression of oral health problems with age among African Americans, thus suggesting that the “earlier aging” of members of racial/ethnic minorities which has been reported in prior research may also be found in oral health.

Keywords

oral health; race/ethnicity; education; age pattern

Introduction

Disparities in oral health by race/ethnicity and by socioeconomic status (SES) have been widely documented.^{1–4} Both African Americans and individuals with low education and income have a higher prevalence of periodontal disease,^{2,3,5} dental caries, tooth loss, and edentulism.^{1,3,6} These disparities in oral health have been attributed to a complex web of social, psychological, and structural factors, such as nutrition, oral hygiene, healthcare utilization, and access to care.^{3,4,7}

Research into other health outcomes, such as the onset of diseases and mortality, suggests that members of racial/ethnic minority groups and those with low-SES “age” earlier or experience earlier onset of age-related problems in the United States and other countries.^{8–10}

Although previous studies^{1–6} have focused on racial/ethnic and socioeconomic inequalities in oral health conditions at a given age, they have not examined disparities in oral health indicators across age ranges. For example, although it is known that the prevalence of periodontal disease increases with age,¹¹ it is not clear to what extent the strength of this association differs by race/ethnicity and education. This paper examines age patterns in oral health indicators by race/ethnicity and education to evaluate differences in the magnitude of educational and racial/ethnic disparities at multiple stages of the life course. Given that prior research has confirmed earlier aging of racial/ethnic and socioeconomic minorities,^{9,10,12} we hypothesize not only that lower educational attainment will be associated with more oral health problems in young adulthood, but also that the magnitude of these differences will be more substantial in later life. Similarly, we expect that being African American (as compared to non-Hispanic White) will also be associated with more oral health problems in young adulthood and comparatively larger disparities in old age. While this paper is largely descriptive, clarification of the differences of age patterns in oral health problems emphasizes the lifecycle nature of their development and can indicate possible disparities both in the timing of onset and progression of disease.

Methods

Data were taken from the National Health and Nutrition Examination Surveys (NHANES) 1999–2004,¹³ a series of cross-sectional studies representative of the civilian, noninstitutionalized population of the United States. These studies consist of interviews, clinical examinations, and laboratory tests. Beginning in 1999–2000, NHANES has collected and released data for 2-year periods. To have a sufficient sample size, this study pools the data across 6 years from NHANES 1999–2000, 2001–2002, and 2003–2004.¹³ Geographical areas containing a high percentage of African American and Mexican American respondents were oversampled, allowing for examination of racial and ethnic differences; these data are representative of the total population when appropriately weighted.

These waves of the NHANES included an examination conducted by a dental professional, allowing for a detailed and accurate analysis of multiple oral health problems. For the periodontal data, two (of four) quadrants (i.e., maxillary right, maxillary left, mandibular right, mandibular left) were randomly chosen to assess loss of attachment and pocket depth. This means that periodontal data were based on an assessment of half of each respondent's teeth. In 1999–2000, only mesial and mid-facial sites were assessed, whereas in 2001–2004 mesial, mid-facial, and distal sites were assessed on each tooth. Tooth loss and caries were assessed for all permanent teeth. Detailed methods on dental examination in NHANES can be found in the NHANES documentation.¹⁴

Our analysis included respondents aged 20 and older who participated in the oral health examination between 1999 and 2004¹³ (n = 13,070). We examined differences between African Americans, Mexican Americans, and non-Hispanic Whites. We excluded respondents who reported their race or ethnicity as “other” race or “other” Hispanic origin (n = 1,055) because these categories were too small to provide meaningful analysis, leaving a sample size of 12,015. Approximately 31% of the sample was taken from 1999–2000¹³ (n = 3,717), 35.5% from 2001–2002¹³ (n = 4,267), and 33.5% from 2003–2004¹³ (n = 4,031). Analyses of caries and periodontitis necessarily excluded the edentulous (n = 1,233) and analyses of periodontitis further excluded those who did not complete the periodontal portion of the survey. Thus, the final sample size was 12,011 for analysis of edentulism, 9,283 for caries, and 9,078 for periodontitis.

We examined three measures of oral health: edentulism, the presence of root caries, and periodontitis. Edentulism was defined as having no permanent teeth. Root caries was defined as the presence of one or more decayed root carious lesions in any permanent tooth. Periodontitis in this study was measured using the case definition for periodontitis developed by the CDC Periodontal Disease Surveillance Workgroup.¹⁵ Subjects with severe (≥ 2 interproximal sites with loss of attachment ≥ 6 mm and ≥ 1 interproximal sites with pocket depth ≥ 5 mm) or moderate (≥ 2 interproximal sites with loss of attachment ≥ 4 mm or ≥ 2 interproximal sites with pocket depth ≥ 5 mm) periodontitis were coded as having periodontitis in our analysis.

The primary independent variables in this study were education and race/ethnicity. Education was divided into three categories: less than a high-school degree (≤ 11 years of education), high-school degree (= 12 years), and some college or more (> 12 years); some college or more was used as the reference group. Race/ethnicity was measured by three categories: African American, Mexican American, and non-Hispanic White (the referent). We also controlled for age in years and gender (female = 1).

The unadjusted prevalence of all three oral health problems by education, race/ethnicity, and age are presented. Next, a series of logistic regression models were developed to estimate the magnitude of the differences by race and education in the age patterning of oral health problems. Separate regressions were run for the three types of oral health problems—edentulousness, caries, and periodontitis.

The form of the equation used was:

$$g=b_0+b_1c_1+b_2c_2+b_3c_3+b_4c_4+b_5c_5+b_6c_6+b_7c_1c_3(\text{or } 5)+b_8c_1c_4(\text{or } 6)$$

where b_1 is the coefficient for age, b_2 is that for gender, b_3 indicates the effect of being African American compared to White, b_4 indicates the effect of being Mexican American compared to White, b_5 is the coefficient for less than a high-school degree versus some college or more, and b_6 is the coefficient for high-school degree versus at least some college. The interaction effects of age and race/ethnicity (or education) are represented by b_7 and b_8 . The interaction term indicated whether there was a difference in the slope of age for African Americans or Mexican Americans relative to Whites and for those of low education relative to high education. To clarify how the variables differed by age, the age “slope” effect for African Americans and for Mexican Americans relative to Whites, and for those with less than a high school degree or a high school degree relative to those with some college or more was evaluated. These equations were used to estimate the predicted probability of oral health problems with age by race/ethnicity and education. In all analyses, survey procedures in SAS (SAS statistical software package version 9.2, SAS Institute, Chicago, IL, USA.) were used to account for the complex sample design of NHANES.

Results

As shown in Table 1, the mean age of respondents in our sample was approximately 46 years. Slightly more than half of the respondents were female, while over half reported at least some college education. Approximately 12% were African American and 8% were Mexican American. More than 7% of the total sample was edentulous, nearly 10% had root caries, and around 7% had periodontitis.

Table 2 shows the weighted population prevalence estimates of edentulism, root caries, and periodontitis by age, education, and race/ethnicity (prevalence of root caries and periodontitis shown for dentate persons only). The prevalence of edentulism in the age range

of 20–34 years was nearly zero for all racial/ethnic and education groups. The prevalence was substantially higher at older ages for all races and education levels; however, the size of the gap was much larger in late life. For example, more than half of African Americans age 80 or older were edentulous, compared to less than one-third of non-Hispanic Whites. Similarly, nearly half of those with less than high-school degree over age 80 were edentulous, compared to only around one-fifth of those with at least some college education. The evaluation for root caries was found to have a similar pattern with regard to race. At ages 20–34, the prevalence of root caries among African Americans was nearly double the prevalence among non-Hispanic Whites; among those age 80+, the prevalence for African Americans was nearly triple that of non-Hispanic Whites. This pattern did not seem to hold for periodontitis; although large racial and educational disparities existed throughout the age ranges examined, these disparities did not appear to be substantially larger in the older age groups.

The regression analysis for the estimated effects of education on edentulousness, presence of root caries, and periodontitis by age are shown in Table 3(a). Having lower educational attainment was strongly associated with higher probability of all types of oral health problems; however, the interaction between age and education was not statistically significant, suggesting that the size of these disparities was constant across age groups. Being older was strongly associated with all three oral health problems. Being female was significantly associated with a lower probability of having root caries and periodontitis. With the other controls in the equation, being African American was associated with higher probability of having root caries and periodontitis, while being Mexican American was significantly associated with a lower likelihood of edentulousness.

Table 3(b) details the relationship between oral health problems with age and being African American or Mexican American. As expected, the interaction of age and being African American was significant in the models predicting edentulousness and root caries. This suggested that African American disparities in oral health were larger at older ages. There were no significant interactions found between age and Mexican American ethnicity.

To more clearly show the magnitude and direction of these disparities indicated in Table 3, Figure 1 presents the predicted probabilities of oral health problems based on the logistic regression models. As shown in Figure 1, those with less than a high-school degree and those with a high-school degree have consistently higher predicted probabilities of edentulousness, root caries, and periodontitis than those with more than a high-school degree in all age groups. Although the disparity by education shown in Figure 1 was greater at older ages for root caries and periodontitis, it was not significantly greater at older ages for those oral health outcomes. In contrast, Figure 1(a) shows that although the predicted probability of being edentulous was relatively similar in younger age groups, the probability of edentulousness increased much more sharply with age for the two lower education groups.

The slower increase in the probability of edentulousness with age resulted in a lower probability of edentulousness in old age among Mexican American subjects than non-Hispanic Whites (Figure 2a). Figures 2(b) and (c) show a rapid rise in the probability with age, clearly indicating the interaction effect between age and race/ethnicity. Disparities in the prevalence of root caries and periodontitis at young ages are quite small, with African Americans having the highest prevalence and Mexican Americans having the lowest prevalence. However, the probabilities for both African Americans and Mexican Americans increase at a much more rapid pace with age compared to non-Hispanic Whites so that by age 80, the predicted probability of having root caries is approximately 30% for African

Americans, 22% for Mexican Americans, and approximately 12% for non-Hispanic Whites (Figure 2b).

Discussion

We found that African Americans and persons with relatively low levels of education experienced more oral health problems at younger ages, and that these disparities were more pronounced at older ages. We found a higher prevalence of edentulism at younger ages among those with less education, and a widening gap with age by education. We also found a higher prevalence of root caries at younger ages and a widening gap with age between African Americans and non-Hispanic Whites. This may indicate a faster progression of oral health problems with age, thus suggesting that the “earlier aging”^{9,10} of members of racial/ethnic minorities and among those with low-education levels demonstrated by prior research may also be found in oral health. This emphasizes the lifecycle nature of the development of oral health problems; more specifically, it highlights the importance of prevention and early intervention for racial/ethnic and socioeconomic minorities in preventing oral health disparities in later life.

Lack of resources to pay for care, either out of pocket or through private or public dental insurance, may be one mechanism leading to disparities by SES and race. In addition, lack of a regular source of care, available transportation to a clinic, or flexibility in getting time off from work to attend to health needs may be more common among minorities and persons with lower education. Disparities may be exacerbated by differentials in treatment^{16,17} and community programs such as fluoridated water, which are less prevalent in low SES areas.¹⁸

Since having dental insurance is an indicator of the availability of care that could affect oral health,¹⁹ additional regression analyses were run to include the current availability of dental insurance in the equations to see whether the direct effects of age, race, and education as well as the interactions of age and race and education were changed with controls for dental insurance (data not shown). We found that even when the presence of current dental insurance is controlled, the effects of being African American remained significant and increased with age. This suggests that having current dental insurance coverage does not explain the observed differences.

Although differentials in oral health at older ages can result from a lifetime of differences, the cross-sectional nature of this analysis does not allow us to control for lifetime differentials in either dental insurance or access to dental care more broadly. The “dental environment” at younger ages such as access to and availability of dental care, appropriate treatment, and community-wide awareness and availability of dental care may have a lifelong effect on oral health, resulting in large disparities in later life. Indeed, at present African American children have been shown to have larger unmet oral healthcare needs,²⁰ which can lead to larger disparities as gaps that accumulate through the life course. Therefore, dental care at younger ages may be the way to reduce the pattern of age differentials.

The higher levels of oral health problems at younger ages in some groups may be an indication of earlier “oral aging.” Although even severe oral health problems can be alleviated with treatment or reversed if treated in their initial stages, without consistent use of treatment over the lifespan, they are unlikely to be eliminated. Edentulousness, in particular, may be highly determined by a cohort's history. Current older cohorts are particularly vulnerable to oral health conditions because they did not receive early dental care, nor did they experience community water fluoridation and use other fluoride products²¹ when they were young. In addition, personal oral hygiene practices were not as

publicly promoted as they are today. Thus, while edentulousness will continue to increase with age, we expect it to be less common among younger cohorts.

In addition, the pattern of racial disparities in edentulism may change in the future. Analysis of our results indicates a low prevalence of edentulism among Mexican Americans at earlier ages and a higher prevalence among African Americans, which suggests that the early life conditions of Mexican Americans, many of whom are migrants, might have been better for their oral health than those of the African American population. Indeed, the health of older Hispanics in general is better than one would expect, given their SES, a phenomenon referred to as the “Hispanic paradox.”²² Immigration selection, combined with good nutrition and health habits among older Hispanics, have been cited as reasons for the Hispanic paradox. However, this phenomenon may not hold true for second-generation Hispanics; consequently, future cohorts may look more similar to the African American population.

Our study is limited by the cross-sectional nature of the data. Although our results show a pattern of age differences that we interpret as “earlier aging,” longitudinal data is necessary to examine age changes rather than age differences. Many of our results may reflect cohort differences rather than age changes. We found that disparities in oral health between African Americans and non-Hispanic Whites were larger in older cohorts. This could indicate “earlier aging” but may also indicate that racial disparities overall were much wider throughout the older cohorts' lifespan, given that these cohorts were born before the civil rights movement. Nevertheless, our results emphasize that when we attend to oral health problems among the elderly, older people's oral diseases are often the consequence of accumulated oral problems and poor health practices over a long period of time—not simply a reflection of their current circumstances and behavior.

Given that older people often have limited availability and access to oral health care, particularly African Americans and those of low SES, these disparities in late life are particularly troubling. Oral health is not an isolated health problem but rather is linked to a number of serious health outcomes associated with aging, including cardiovascular disease, stroke, and mortality.^{11,23–27} Thus, closing the gap in childhood oral health may indirectly influence racial and socioeconomic disparities in other forms of health.

Conclusions

These results may indicate a faster progression of oral health problems with age among African Americans, thus suggesting that the “earlier aging” of members of racial/ethnic minorities reported by other authors^{9,10} may also be found in oral health.

Acknowledgments

This work was supported by the National Institute of Dental And Craniofacial Research Grant 1R21DE019950-01.

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Figure 1.

Predicted probability of oral health problems by education and age, NHANES 1999–2004.

(a) Edentulousness, (b) root caries, and (c) periodontitis.

Note: Predicted probabilities are calculated based on logistic regression estimates [See Table 3(a)] of the effect of education on oral health problems.

Figure 2.

Predicted probability of oral health problems by race/ethnicity and age, NHANES 1999–2004.

(a) Edentulousness, (b) root caries, and (c) periodontitis.

Note: Predicted probabilities are calculated based on logistic regression estimates [See Table 3(b)] of the effect of race/ethnicity on oral health problems.

Table 1

Sample characteristics, NHANES 1999–2004 (N = 12,011).

Characteristic	% (SE)	M (SE)
Age		46.0 (0.30)
Female	51.5 (0.48)	
Race/Ethnicity		
African American	11.8 (1.08)	
Mexican American	7.7 (0.94)	
White non-Hispanic	80.6 (1.35)	
Education		
Less than high school degree	19.0 (0.74)	
High school degree	26.6 (0.83)	
Some college/college degree	54.5 (1.24)	
Oral health		
Edentulous	7.7 (0.56)	
Has root caries	9.8 (0.86)	
Has periodontitis	7.4 (0.53)	

SE = Standard error.

Table 2

Percentage (SE) with oral health problems among adults age 20+ by age; weighted population estimates NHANES 1999–2004.

	Edentulism				Root caries *				Periodontitis *			
	By Education											
Age groups	Less than high school degree	High school degree	Some college	Less than high school degree	High school degree	Some college	Less than high school degree	High school degree	Some college	Less than high school degree	High school degree	Some college
20–34	0.0 (0.0)	0.6 (0.3)	0.4 (0.2)	13.7 (1.5)	10.6 (1.5)	3.1 (0.4)	4.3 (1.0)	1.2 (0.7)	3.1 (0.4)	4.3 (1.0)	1.2 (0.7)	0.5 (0.2)
35–49	6.1 (1.5)	3.9 (0.7)	1.1 (0.3)	24.8 (2.5)	13.5 (1.6)	6.6 (0.9)	17.9 (2.1)	7.1 (1.0)	6.6 (0.9)	17.9 (2.1)	7.1 (1.0)	3.3 (0.4)
50–64	23.5 (2.6)	14.9 (1.2)	4.6 (0.7)	22.1 (2.8)	12.2 (2.0)	7.0 (0.8)	26.5 (3.0)	14.0 (2.1)	7.0 (0.8)	26.5 (3.0)	14.0 (2.1)	8.6 (0.7)
65–79	42.6 (3.4)	25.0 (2.5)	11.5 (1.5)	23.6 (2.8)	13.3 (1.9)	7.9 (1.5)	36.0 (2.8)	18.8 (2.4)	7.9 (1.5)	36.0 (2.8)	18.8 (2.4)	16.1 (2.1)
80+	47.1 (3.3)	35.6 (4.3)	20.2 (2.5)	26.3 (3.6)	18.8 (3.8)	10.7 (3.0)	28.6 (4.4)	27.3 (4.4)	10.7 (3.0)	28.6 (4.4)	27.3 (4.4)	17.3 (2.9)
By Race/Ethnicity												
Age groups	African American	Mexican American	Non-Hispanic White	African American	Mexican American	Non-Hispanic White	African American	Mexican American	Non-Hispanic White	African American	Mexican American	Non-Hispanic White
20–34	0.0 (0.0)	0.1 (0.1)	0.5 (0.2)	11.8 (1.3)	6.7 (1.1)	6.2 (0.7)	2.5 (0.6)	2.0 (0.6)	6.2 (0.7)	2.5 (0.6)	2.0 (0.6)	1.1 (0.3)
35–49	2.3 (0.7)	0.6 (0.3)	2.8 (0.5)	21.5 (2.1)	12.1 (1.4)	9.2 (1.0)	15.2 (1.6)	8.2 (1.4)	9.2 (1.0)	15.2 (1.6)	8.2 (1.4)	4.7 (0.5)
50–64	13.1 (1.4)	4.9 (1.5)	10.5 (1.1)	22.7 (2.9)	16.4 (1.6)	8.7 (0.9)	19.5 (2.2)	19.8 (3.3)	8.7 (0.9)	19.5 (2.2)	19.8 (3.3)	11.2 (1.0)
65–79	28.5 (2.0)	19.5 (2.2)	24.4 (1.9)	27.1 (2.7)	26.3 (2.0)	11.1 (1.3)	31.4 (2.9)	25.8 (3.5)	11.1 (1.3)	31.4 (2.9)	25.8 (3.5)	20.1 (1.5)
80+	53.1 (6.5)	35.3 (6.1)	32.4 (2.3)	44.2 (9.4)	40.3 (9.1)	15.4 (2.2)	33.2 (10.1)	56.3 (11.2)	15.4 (2.2)	33.2 (10.1)	56.3 (11.2)	22.1 (2.2)

SE = Standard Error.

* Prevalence among dentate adults 20+ only.

Table 3

Odds ratios from logistic regression, indicating the association of education and race/ethnicity on oral health problems, NHANES 1999–2004.

(a) Including interactions of age and education						
	Edentulousness		Root caries		Periodontitis	
	ORs	95% CI	ORs	95% CI	ORs	95% CI
Age in years	1.078	1.068–1.089	1.022	1.014–1.030	1.070	1.062–1.077
Female	1.026	0.859–1.225	0.661	0.578–0.757	0.499	0.406–0.612
(White as reference)						
African American	0.823	0.645–1.050	2.056	1.639–2.579	1.946	1.540–2.458
Mexican American	0.266	0.168–0.422	0.821	0.616–1.095	0.908	0.628–1.312
(College or more as reference)						
Less than high school degree	6.948	2.785–17.334	5.606	3.226–9.742	11.288	6.654–19.149
High school degree	4.265	1.957–9.291	3.721	2.070–6.690	3.242	1.806–5.820
Age × Less than high school degree	0.997	0.983–1.011	0.992	0.983–1.002	0.980	0.971–0.990
Age × High school degree	0.994	0.982–1.006	0.990	0.979–1.000	0.989	0.978–0.999
N	12,011		9,283		9,078	
Wald (df)	1,923.73 ($p < 0.0001$)		649.96 ($p < 0.0001$)		1,488.15 ($p < 0.0001$)	
(b) Including interactions of age and race/ethnicity						
Age in years	1.071	1.065–1.077	1.012	1.008–1.016	1.058	1.051–1.065
Female	1.022	0.855–1.222	0.657	0.575–0.751	0.494	0.404–0.604
(White as reference)						
African American	0.214	0.088–0.520	1.265	0.869–1.841	2.334	1.311–4.154
Mexican American	0.021	0.005–0.087	0.309	0.172–0.556	0.520	0.249–1.087
(College or more as reference)						
Less than high school degree	5.786	4.662–7.183	3.853	2.999–4.950	3.824	3.034–4.821
High school degree	2.909	2.454–3.447	2.333	1.892–2.876	1.748	1.407–2.172
Age × African American	1.023	1.010–1.036	1.011	1.004–1.019	0.996	0.986–1.007
Age × Mexican American	1.043	1.023–1.063	1.024	1.014–1.035	1.013	1.001–1.025
N	12,011		9,283		9,078	
Wald (df)	2,500.72 ($p < 0.0001$)		840.74 ($p < 0.0001$)		2,115.77 ($p < 0.0001$)	

ORs = Odds ratios.