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Perception of general and oral health in White and African American adults: assessing the effect of neighborhood socioeconomic conditions[1]

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Abstract – *Objectives:* This study investigates the independent and joint effects of family income and neighborhood socioeconomic status (SES) on general health and oral health before and after controlling for traditional risk factors in a representative sample of adults aged 18+ years residing in the Detroit tri-county area, Michigan. *Methods:* Individuals data were obtained through interviews, while neighborhood data came from the 1990 US Census. SUDAAN was used to accommodate the complex sampling design and correlation of outcomes within the same neighborhoods. *Results:* Whites in disadvantaged neighborhoods were four times more likely to rate their oral health as fair or poor [odds ratio (OR): 4.0; 95% confidence intervals (CI): 1.6–10.3] than their counterparts in advantaged neighborhoods. When evaluating the joint effects of family income and neighborhood SES, low-income Whites in disadvantaged neighborhoods were six times more likely to rate their oral health as fair or poor (OR: 6.4; 95% CI: 1.6–26.5) than their high-income counterparts in advantaged neighborhoods. The odds of rating general health as fair or poor was six times greater in low-income African Americans in disadvantaged neighborhoods (OR: 6.1; 95% CI: 1.6–23.8) than high-income African Americans in advantaged neighborhoods. Similarly, low-income African Americans in disadvantaged neighborhoods were almost three times (OR: 2.8; 95% CI: 1.0–8.1) more likely to rate their oral health as fair/poor than high-income African Americans in advantaged neighborhoods. *Conclusions:* SES conditions at the neighborhood-level, independently or jointly with individual-level income, appear to be important in evaluating racial/ethnic differences in self-rated oral health. Neighborhood conditions could tap into constructs not captured by individual-level variables on self-rated oral health.

Key words: neighborhood effects; perception of general health; perception of oral health; race/ethnicity; United States

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Self-rated general health and oral health are well-known indicators of individuals' views of their health as well as valid predictors of access to health care (1–5). Furthermore, self-rated health is a powerful predictor of mortality (6). Both self-rated general health and oral health have been associated with individual socioeconomic characteristics and race/ethnicity (3, 4). When compared with Whites and individuals with high socioeconomic status (SES), African Americans and individuals with low

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SES are, on average, more likely to rate their general health and oral health as poorer (3, 4).

In addition to the body of literature supporting an association between individuals' characteristics and self-rated general health, an extant body of research reports an association between neighborhood characteristics and self-rated general health (7–18). These studies suggested that individuals living in disadvantaged neighborhoods are more likely to rate their general health as poor than their counterparts living in more advantaged neighborhoods, regardless of their SES. Despite the existing evidence for the association between self-rated health status and neighborhood characteristics, to date, no study has explored a similar association for self-rated oral health in the United States. However, in Canada, Locker and Ford (19, 20) found that individuals living in low-income areas were more likely to rate their oral health as fair or poor than those living in high-income areas.

Although the mechanisms by which neighborhood socioeconomic conditions operate to influence self-rated general health are not well-understood, it has been suggested that neighborhood conditions affect self-perception of general health by influencing health behaviors, promoting diffusion of health-related information, and increasing the adoption of healthy normative behaviors (21). Therefore, the same dynamics could operate to affect individuals' perception of oral health. For example, neighborhoods' conditions (such as the number of dental providers and clinics) could facilitate promotion of healthy behaviors such as regular checkup visits and dissemination of oral health-related information to members of the community.

In this paper, we investigate (i) the independent effects of family income and neighborhood socioeconomic conditions on self-rated (a) general health and (b) oral health; and (ii) the joint effect of family income and neighborhood socioeconomic conditions on self-rated (a) general health and (b) oral health before and after controlling for other relevant individual-level characteristics. In addition, we examine whether the relationship between neighborhood socioeconomic conditions and self-rated general health and oral health varies by race/ethnicity.

Methods

This study analyzes data collected in a population-based study conducted in the Detroit tri-county area in Michigan during 1994 among a disproportionate probability sample of adults aged 18 years or older living in housing units (i.e. apartments or single-family houses) (22–24). Sampling was conducted utilizing a stratified, clustered, area probability sampling technique based on census tracts. To maximize the ability to compare African Americans with Whites and to separate the effect of SES from race/ethnicity, the sampling design was disproportionate, with African Americans oversampled and African Americans in higher income census tracts further oversampled. One randomly selected adult from each selected housing unit was interviewed face-to-face. The response rate for the interview was 71% ($n = 787$). Ninety-six percent of those interviewed were linked to block-group data using their home address ($n = 755$). However, this analysis was limited to participants with information on both self-rated general and oral health. From the 563 records available for analysis, we excluded 28 individuals who were neither non-Hispanic African Americans nor non-Hispanic Whites. A total of 535 subjects in 116 block groups (with a median of five participants per block group, ranging from one to 14) were available for analysis. The Institutional Review Board at the University of Michigan approved the study protocol and written informed consent was obtained from each participant. Further, the Institutional Review Board at Columbia University approved an expedited review for these analyses.

Perception of general health was collected during the in-home exam visit and was assessed using the question 'Would you say your health in general is excellent, very good, good, fair, or poor?' Perception of oral health was collected during the first contact interview by professional interviewers without any dental background to ensure that the responses would not be influenced by the fact that the interviewer subsequently would assess the respondent's oral health status. Perception of oral health was assessed by the question 'Overall, would you rate the health of your mouth, teeth, and gums, as excellent, good, fair or poor?' As in previous studies (7–10, 13), the outcomes were dichotomized for analysis as follows: one category for those who responded excellent, very good, or good to the item on overall health and excellent or good to the item on oral health, and another category for those responding fair or poor for each of the two outcomes.

Race/ethnicity was determined from a combination of the questions used to ascertain race and

ethnicity. Ethnicity was established from the question: 'Do you consider yourself Hispanic or Latino?' Race was determined from the question: 'Do you consider yourself primarily white or Caucasian, Black or African American, Asian or Pacific Islander, or American Indian, Eskimo, or Aleut?' This analysis was limited to non-Hispanic White and non-Hispanic Black or African American (From hereafter, White and African American). Education level was collected as a continuous variable from zero to 17 years and was later categorized in three groups: <12 years of schooling, 12 years, and >12 years of schooling. Family income was established from the item: 'What was (your/your family's) total combined income in 1993 before taxes, including salaries, wages, pensions, dividends, interest, and all other income?' and was subsequently categorized as follows: <$20 000; $20 000 to 39 999; and ≥$40 000. Other covariates considered in previous studies (4, 7, 9, 10, 13, 25) and used in these analyses include age, gender, marital status, self-reported diabetes, and smoking.

Census block groups were used as proxies for neighborhoods. Block groups are subdivisions of census tracts with an average of 1000 residents. A neighborhood SES score was developed to summarize neighborhood conditions. This score was based on factor analyses of multiple 1990 US Census variables as reported elsewhere (26, 27). Briefly, six variables representing the dimensions of wealth/income (log of the median household income, log of the median value of owner occupied housing units, and the proportion of households receiving interest, dividend or net rental income), education (the proportion of adults aged 25 years or older with a high school diploma and the proportion of adults aged 25 years or older with completed college education), and occupation (the proportion of employed persons aged 16 years or older in executive, managerial, or professional specialty occupations) were combined into the score. Each variable was transformed to a *z*-score by subtracting its value from the grand mean for that variable and dividing the result by the standard deviation of the grand mean. The score for each block group was calculated as the sum of the *z*-scores of the individual factors. These scores ranged from −10.3 to 14.6, with increasing values reflecting increasing neighborhood socioeconomic advantage. Neighborhood socioeconomic disadvantage as assessed using this score has previously found to be related to coronary heart disease in the Atherosclerosis Risk in Communities (ARIC) cohort (26, 28) and to other cardiovascular-related outcomes in another cohort (29, 30). In addition to the neighborhood SES score, variables representing minority composition and percent of people living below the poverty level were included in the analyses.

Statistical analysis

Because of differences in distribution of neighborhood socioeconomic indicators by race/ethnicity, the neighborhood SES score was divided into racial/ethnic-specific tertiles and analyses were racial/ethnic-specific. Individual and neighborhood characteristics were compared within each racial/ethnic group by each of the two outcomes. Logistic regression was used to estimate odds ratios (OR) and 95% confidence intervals (CI) for the association of both outcomes (self-rated general and oral health) and neighborhood SES score and family income, respectively. Specifically, three sets of analyses were performed for self-rated general and oral health by neighborhood SES tertiles and family income categories: (i) to estimate crude ORs, (ii) to estimate OR adjusted for age and gender (model 1, separate model for family income and neighborhood SES score), and (iii) to estimate ORs adjusted for age, gender, marital status, diabetes, smoking, and education (model 2). In addition, the OR estimates in model 2 for neighborhood SES score and individual income were mutually adjusted (i.e. neighborhood SES score was adjusted for family income and vice versa). Trend tests were conducted by including the neighborhood score tertiles and income categories as ordinal variables in the models.

To examine the joint effects of neighborhood SES score and income, nine cross-classified categories of neighborhood SES score and family income were created (e.g. lowest income tertile and lowest tertile of the neighborhood SES scores, middle income tertile and middle tertile of the neighborhood SES scores, highest income tertile and highest tertile of the neighborhood SES scores, etc). Specifically, we were interested in comparing self-rated general and oral health for those low in both family income and neighborhood SES score to those high in both family income and neighborhood SES score. Logistic regression was used to estimate the association of each outcome (general and oral health) with the joint effect of family income and neighborhood SES score before and after adjusting for age, gender, marital status, diabetes, smoking, and education.

Interactions between neighborhood SES score and family income were tested.

All analyses were conducted using SUDAAN (31) to account for the complex sampling design and to estimate valid standard errors. In addition, because the small number of subjects per block group and consistent with previous studies, SUDAAN was used to account for the intra-neighborhood correlation of outcomes (26, 32–34). Therefore, the odds ratios reported are population-averaged rather than unit-specific estimates. In the tables, the samples sizes are unweighted, while means, proportions, standard errors and ORs with their 95% CIs are weighted to represent the two racial/ethnic groups in the Detroit tri-county area.

Results

African Americans generally lived in more disadvantaged neighborhoods than Whites as illustrated in Table 1 by lower values for each of the neighborhood SES characteristics associated with wealth/income, education, or occupation and higher value for neighborhood poverty in each of the score tertiles. Overall, twelve percent rated their general health as fair or poor (data not shown), with African Americans exhibiting almost twice the prevalence (16%) as Whites (8.2%) (Table 2). Whites and African Americans who rated their general health as fair or poor were older, less educated, had lower income, and were more likely to have diabetes than their counterparts who rated their general health as excellent, very good or good. In general, those who rated their general health as fair or poor were more likely to live in neighborhoods with worse SES conditions, regardless of their race/ethnicity. Of all participants, 37% rated their oral health as fair or poor (data not shown). African Americans were more likely to rate their oral health as fair or poor (46.2%) than Whites (26.3%) (Table 3). Whites who rated their oral health as fair or poor were younger, less educated, had lower income, and were more likely to smoke than their counterparts who rated their oral health as excellent or good. African Americans who rated their oral health as fair or poor had lower income than African Americans who rated their oral health as excellent or good.

Table 4 presents the results of crude analysis and multivariable modeling for the associations between family income and neighborhood SES score and self-rated general and oral health. The associations between self-rated general health and neighborhood SES score and family income were reduced after additional adjustment for marital status, diabetes, smoking, education, and family income/neighborhood SES score (model 1 versus model 2). However, the association remains significant for family income in African Americans only: low-income African Americans were 3.7 times (95% CI: 1.1–12.2) more likely to rate their general health as fair or poor than their high-income peers after adjusting for traditional risk factors and also for education and neighborhood SES score.

As with self-rated general health, the ORs of fair or poor oral health ratings by neighborhood SES categories were reduced after additional adjustment for marital status, diabetes, smoking, family income, and education (model 1 versus model 2, Table 4). However, this association remains significant for Whites: Whites living in neighborhoods in the lowest tertile of the SES score were four times (95% CI: 1.6–10.3) more likely to rate their oral health as fair or poor than their peers living in the neighborhoods in the highest tertile of the score. As with general health, the association between perception of oral health and family income was significant for African Americans. Low-income African Americans were more than twice (OR: 2.3; 95% CI: 1.2–4.4) as likely to rate their oral health as fair or poor than their high-income counterparts.

When compared with high-income African Americans living in the most advantaged neighborhoods: being low-income African American and living in the lowest tertile of the neighborhood SES score increase the odds of rating one's general health as fair or poor sixfold (Table 5). The joint effect of family income and neighborhood SES score significantly increases the odds of rating oral health as fair or poor for both Whites and African Americans. However, the odds of rating their oral health as fair or poor for low-income African Americans living in the most disadvantaged neighborhoods (OR: 2.8; 95% CI: 1.0–8.1) was lower than the odds of their White peers (OR: 6.4; 95% CI: 1.6–26.5).

In general, differences across neighborhoods appeared to be smaller and less consistent in the highest family income category than in the lowest category but the test for interaction was not statistically significant (data not shown).

These results remained essentially unchanged when additional analyses were performed for each outcome, controlling for percent minority, and for

Table 1. Neighborhood characteristics according to neighborhood socioeconomic status (SES) summary score tertiles in White and African Americans

Characteristics	Whites			African Americans		
	Lowest (z-score, −9.2 to 1.14)	Middle (z-score, 1.15 to 4.78)	Highest (z-score, 4.79 to 14.6)	Lowest (z-score, −10.3 to −4.27)	Middle (z-core, −4.28 to −1.62)	Highest (z-score, −1.63 to 10.3)
Study participants (*n*)	76	85	86	103	84	101
Neighborhoods (*n*)	28	24	18	20	16	22
Neighborhood SES score mean[a]	−2.5	2.8	8.4	−7.0	−3.2	1.5
Median household income ($)	24 627	42 633	63 084	16 736	26 167	41 444
Median value of housing units ($)	49 323	81 996	140 137	19 606	30 471	50 934
Households earning interest, dividends or rental income (%)	29	53	67	11	17	34
Adult residents who completed high school (%)	64	82	91	52	69	80
Adult resident who completed college (%)	9	17	42	4	9	22
Employed residents with executive, managerial, or professional occupations (%)	15	26	49	10	14	30
Minority composition (%)[b]	15	3	5	88	91	69
Living below poverty level (%)[b]	17	4	2	42	26	9

[a]Neighborhood SES score defined as a *z*-score using the mean and standard deviation of the total population (i.e. value are one standard deviation above or below the grand mean).
[b]Not included in the neighborhood SES score.

Table 2. Individual and neighborhood characteristics by self-rated general health according to race/ethnicity

Characteristics	Self-rated general health			
	Whites ($n = 244$)		African Americans ($n = 282$)	
	Excellent, very good or good	Fair or poor	Excellent, very good or good	Fair or poor
Individual				
Prevalence (%)	91.8	8.2**	84.0	16.0**
Age in years (mean ± SE)	45.5 (17.3)	59.3 (16.1)*	40.4 (15.3)	51.7 (15.1)*
Male (%)	45.5	42.9	41.1	26.1
Marital status (%)				
Married	57.1	23.8	35.0	28.3
Unmarried	42.9	76.2**	65.0	71.7
Education (%)				
<12 years	8.7	57.1	16.9	37.0
= 12 years	34.2	38.1	28.4	32.6
>12 years	57.1	4.8**	54.7	30.4**
Family income (%)				
<$20 000	20.3	61.9	33.7	58.7
$20k to 39 999	21.2	28.6	27.6	28.3
≥$40k	58.4	9.5**	38.7	13.0**
Diabetes (yes) (%)	2.2	9.5*	5.8	23.9**
Current smokers (%)	30.7	38.1	32.5	37.0
Neighborhood				
Neighborhood SES score mean	3.5	−1.7**	−2.6	−4.4**
Median household income ($)	45 819	25 596**	28 921	23 410*
Median value of housing units ($)	95 577	49 925**	34 625	28 658*
Households earning interest, dividends or rental income (%)	52	37**	21	17
Adult residents who completed high school (%)	81	64**	68	61*
Adult resident who completed college (%)	24	13**	13	7**
Employed residents with executive, managerial, or professional occupations (%)	32	20**	18	13**
Minority composition (%)	7	15**	81	87
Living below poverty level (%)	6	19**	25	31

Chi-square or *t*-test *$P < 0.05$; **$P < 0.01$.

percent living below the poverty level (data not shown).

Discussion

Both neighborhood and individual socioeconomic characteristics were associated with self-rated general and oral health in adults in the Detroit tri-county area, Michigan. However, these associations differ by race/ethnicity: neighborhood disadvantage was associated with self-reported oral health in Whites; while individual income was associated with both self-rated general and oral health in African Americans. Furthermore, the joint effect of neighborhood SES score and family income was associated with self-rated oral health in both Whites and African Americans but the association was twice as strong in Whites as in African Americans.

Previous studies in the US and other countries have found a negative association between neighborhood disadvantage and self-rated general health (7–18), although others have not (35, 36). In general, these studies have found weak to moderate effects on self-rated general health after controlling for personal socioeconomic indicators. These studies have generally used national samples and have focused on different geographic areas, such as states, census tracts, and block groups as proxies for relevant areas. The area variables investigated have included social capital, poverty areas, median household income, education, Gini coefficient, mistrust, collective efficacy, percent of unemployment, percent of female-headed households, or indices combining some of these variables (7–18, 35, 36). In addition, African Americans on average have been found to be more likely to rate their general health as fair or poor than their White counterparts. For example, Yen

Table 3. Individual and neighborhood characteristics by self-rated oral health according to race/ethnicity

Characteristics	Self-rated oral health			
	Whites ($n = 247$)		African Americans ($n = 288$)	
	Excellent or good	Fair or poor	Excellent or good	Fair or poor
Individual				
Prevalence (%)	73.7	26.3**	53.8	46.2
Age in years (mean ± SE)	48.3 (18.7)	42.9 (15.7)*	41.5 (15.7)	43.2 (15.8)
Male (%)	43.9	47.0	42.9	33.6
Marital status (%)				
Married	55.0	50.0	37.9	30.6
Unmarried	45.0	50.0	62.1	69.4
Education (%)				
<12 years	8.9	22.7	19.9	20.1
= 12 years	33.9	37.9	24.8	33.6
>12 years	57.1	39.4**	55.3	46.3
Family income (%)				
<$20 000	19.6	37.9	31.1	45.5
$20k to 39,999	21.7	21.2	26.7	28.4
≥$40k	58.7	40.9**	42.2	26.1**
Diabetes (yes) (%)	2.1	6.1	8.7	8.2
Current smokers (%)	26.5	43.9**	31.7	33.6
Neighborhood				
Neighborhood SES score mean	4.1	0.2**	−2.2	−3.5
Median household income ($)	47 606	34 713	30 063	25 925
Median value of housing units ($)	100 951	67 646	36 329	30 770
Households earning interest, dividends or rental income (%)	54	41	22	19
Adult residents who completed high school (%)	82	72	69	64
Adult resident who completed college (%)	26	15	14	9
Employed residents with executive, managerial, or professional occupations (%)	34	22	20	16
Minority composition (%)	7	10	83	81
Living below poverty level (%)	6	11	24	28

Chi-square or *t*-test *$P < 0.05$; **$P < 0.01$.

and Kaplan, using data from the Alameda County Study, Oakland, CA, found that individuals who rated their health as excellent/good in 1965 experienced higher risk for rating their general health as fair to poor in 1974 if they lived in a poverty area (9). This association was independent of individual income, education, age, gender, race, smoking status, BMI, and alcohol consumption. Kennedy et al. (13) using data from the Behavioral Risk Factor Survey and the Gini coefficient from the 1990–1992 Current Population Survey also found higher odds of rating general health as fair to poor in people who live in states with higher values of the Gini coefficient after adjusting for family income. In both studies, African Americans were more likely to rate their health as fair to poor than Whites. In contrast to previous studies, we did not find an association between neighborhood disadvantage and self-rated general health. Ours study null finding could reflect the fact that study's participants were recruited from a single community leading to homogeneity of the neighborhood characteristics to certain degree. In addition, previous studies have included race as an independent covariate, while we performed race-specific analyses because of the different distribution in family income and neighborhood socioeconomic conditions between Whites and African Americans in our study.

Although no prior study has examined the association between self-rated oral health and neighborhood characteristics in the US, this relationship has been studied in Canada. Locker and Ford (19, 20), in two separate studies of older White populations, found that individuals living in low-income areas were more likely to rate their oral health as fair or poor than those living in high-income areas. However, the associations with area-based socioeconomic measures were weaker than for individual socioeconomic measures.

Table 4. Racial/ethnic-specific odds ratios and 95% confidence intervals for self-rated general health and oral health by neighborhood SES score and family income

	Fair/poor general health status			Fair/poor oral health status		
Characteristics	Crude	Model 1[a]	Model 2[b]	Crude	Model 1[a]	Model 2[b]
Whites						
Neighborhood SES score tertile						
Low	9.7 (1.2–77.3)	12.1 (1.8–79.5)	5.9 (0.8–45.8)	6.5 (2.6–16.3)	6.7 (2.6–17.0)	4.0 (1.6–10.3)
Medium	2.0 (0.2–21.5)	3.1 (0.3–28.2)	2.5 (0.2–26.9)	2.3 (0.9–5.9)	2.0 (0.8–5.3)	1.8 (0.7–4.6)
High	1.0	1.0	1.0	1.0	1.0	1.0
P-trend	0.04	0.01	0.14	0.0002	0.0001	0.02
Family income						
<$20 000	18.2 (4.3–76.9)	18.6 (3.3–104.5)	2.9 (0.5–16.9)	2.8 (1.2–6.7)	3.9 (1.5–9.9)	1.7 (0.6–4.7)
$20 000–$39 999	6.6 (1.2–35.0)	5.6 (0.9–32.9)	2.7 (0.5–15.1)	1.4 (0.6–3.2)	1.8 (0.8–4.1)	1.2 (0.5–3.0)
≥$40 000	1.0	1.0	1.0	1.0	1.0	1.0
P-trend	0.001	0.001	0.40	0.04	0.007	0.61
African Americans						
Neighborhood SES score tertile						
Low	2.9 (1.2–7.1)	2.9 (1.2–6.8)	1.5 (0.6–4.2)	1.6 (0.8–2.9)	1.5 (0.8–2.9)	1.1 (0.5–2.3)
Medium	1.9 (0.8–4.8)	1.9 (0.7–5.1)	1.6 (0.5–4.6)	1.3 (0.6–2.6)	1.3 (0.6–2.7)	1.1 (0.5–2.3)
High	1.0	1.0	1.0	1.0	1.0	1.0
P-trend	0.05	0.06	0.64	0.42	0.45	0.96
Family income						
<$20 000	5.0 (2.3–11.1)	4.1 (1.8–9.6)	3.7 (1.1–12.2)	2.4 (1.3–4.3)	2.2 (1.3–4.0)	2.3 (1.2–4.4)
$20 000–$39 999	2.7 (1.1–7.0)	2.3 (0.9–5.8)	2.4 (0.9– 6.4)	1.8 (1.0–3.1)	1.7 (0.9–3.0)	1.7 (0.9–3.1)
≥$40 000	1.0	1.0	1.0	1.0	1.0	1.0
P-trend	0.001	0.003	0.07	0.01	0.02	0.03

[a]Model 1: age and gender.
[b]Model 2: age, gender, marital status, diabetes, smoking and SES indicators (education and income for neighborhood SES score; education and neighborhood SES score for income).

Table 5. Racial/ethnic-specific odds ratios and 95% confidence intervals for self-rated general health and oral health by the joint effect of neighborhood SES score and family income

	Fair/poor general health status			Fair/poor oral health status		
Characteristics	Crude	Model 1[a]	Model 2[b]	Crude	Model 1[a]	Model 2[b]
Whites						
Joint effect of neighborhood SES score and family income						
Low-low	4.7 (0.6–36.4)	8.7 (1.2–64.4)	3.8 (0.3–50.3)	8.1 (2.3–28.5)	9.6 (2.6–36.3)	6.4 (1.6–26.5)
High-high	1.0	1.0	1.0	1.0	1.0	1.0
African Americans						
Joint effect of neighborhood SES score and family income						
Low-low	8.0 (1.9–32.7)	6.8 (1.8–25.9)	6.1 (1.6–23.8)	2.8 (1.2–6.8)	2.7 (1.1–6.5)	2.8 (1.0–8.1)
High-high	1.0	1.0	1.0	1.0	1.0	1.0

[a]Model 1: age and gender.
[b]Model 2: age, gender, marital status, diabetes and smoking and education.

Our study found a racial/ethnic differential for the associations of self-rated general and oral health with neighborhood SES and individual income. Socioeconomic conditions at the neighborhood-level were significantly associated with self-rated oral health in Whites, while family income was associated with self-rated general and oral health in African Americans. The lack of identification of significant associations between self-rated general and oral health and neighborhood SES characteristics in African Americans could be because of the fact that African Americans generally tend to live in more disadvantaged neighborhoods, and in fact, there was less variation between their neighborhood characteristics than for Whites' neighborhood characteristics. Moreover, there was very little overlap between African American and White neighborhoods: In general, characteristics (i.e. median household income, median value of owner occupied housing units, percent adults with

completed high school, percent households earning interest) of African American neighborhoods in the highest textile of the neighborhood SES score fell between those of White American neighborhoods in the lowest and middle tertiles of the neighborhood SES score (Table 1). This finding is consistent with a previous analysis of the 171 largest cities in the US (37) in which Sampson and Wilson concluded: 'The worst context in which Whites reside was considerably better than the average context of black communities.'

Although we did not find a statistically significant interaction between neighborhood SES score and family income in their associations with self-rated general and oral health, we investigate the combined effect of neighborhood SES score and family income because of the variability of family income across neighborhood SES tertiles. We found a negative association between low family incomes and living in the most disadvantaged neighborhoods with perception of oral health in both Whites and African Americans. This finding is important because family income and neighborhood SES characteristics are linked in everyday life. It has been suggested that in order to tease out compositional from contextual effects, the best estimates of SES differential are obtained by comparing people in the extremes, people high in both indicators versus people low in both indicators (26). It is worth noting that low-income African American living in the most disadvantaged areas had lower odds of fair/poor self-rated oral health than their White counterparts. This finding could have resulted from the fact that African Americans were more likely to rate their oral health as poor to begin with, regardless of their income or their neighborhood SES conditions (data not shown). Therefore, the magnitude of the association may be attenuated because of a tendency for African Americans across income groups and neighborhood SES tertiles to be more similar in self-rated oral health than Whites.

Among the strengths of our study are the sampling design and population-based nature of the sample and the availability of information on both outcomes in the same dataset. However, sample size limitations may have hindered our ability to detect significant associations in both White and African Americans as well as to detect significant effects of interactions between neighborhood SES score tertiles and income categories. Therefore, our findings regarding weaker or non-significant associations should be interpreted with caution and investigated further. The use of crude definitions of neighborhoods and the use of aggregate SES census measures as indirect proxies for the specific neighborhood attributes could also have limited our ability to detect the effects of neighborhood SES conditions. Studies in the US have generally used census tracts (mean population 4000) or clusters of census tracts as proxies for relevant areas (14, 38–43). We chose block groups for our analyses because previous studies had suggested that block groups would identify smaller areas more akin to neighborhoods than census tracts (38, 44). Recent analyses suggest that estimates of contextual effects are generally similar for block groups or census tracts (27, 29). While it has been suggested that aggregate SES measures represent summaries of individual SES characteristics and that their effects are hard if not impossible to separate from the individual-level SES indicators' effects (45), we did not find strong correlations between neighborhood SES score and family income and education (Spearman $r = 0.41$ and 0.39, respectively), suggesting that these variables may be tapping into constructs not captured by neighborhood SES conditions. In addition, we found appreciable variability in the distribution of income and education levels across neighborhood SES score tertiles (data not shown). The latter indicates that neighborhood SES conditions could have a differential effect on individuals independent of their SES. Because of the cross-sectional nature of the data, the issue of reverse causation cannot be ignored. It is possible that people who rate their health as fair or poor end up in neighborhoods with worse socioeconomic conditions. Furthermore, the lack of information on long-term residential stability in the study participants could limit interpretation of the neighborhood effects found. However, data from the 1990 US Census show that residents in Detroit tend to be relatively stable (70% live in the same house for the past 5 years) (46). Moreover, existing evidence suggests that when people move, most persons tend to move to similar neighborhoods (26, 47). Therefore, we believe that the effects found are meaningful and real. Finally, the difference in scale between the questions for self-rated general (five point) and oral health (four point) could lead to information bias by leading participants to poorer ratings of their oral health. However, any misclassification because of using a four-point scale for self-rated oral health would have been nondifferential and would have driven the association between self-rated oral health and income and

neighborhood SES score towards the null, leading to an underestimation of our results.

Our results indicate that although the effect of SES conditions at the neighborhood-level, i.e. the neighborhood SES score, on self-rated oral health was present in Whites only, they were independent of individual-level SES characteristics. These findings suggest that SES measures at the neighborhood-level could tap into constructs not captured by individual-level variables. While the mechanisms by which neighborhood SES conditions affect health in general are not well understood, it has been postulated that area of residence influences an individual's health behaviors and health-related norms (21, 26). In the case of self-rated oral health, neighborhood SES conditions can influence health behaviors, promote diffusion of health-related information, and increase the adoption of healthy behaviors, all of which further could contribute to prevent the clinical occurrence or progression of dental decay and periodontal disease. Determining whether the association between neighborhood SES conditions and self-rated oral health reflect causal processes will require focused investigation of the specific processes through which features of residential areas may affect health -or norms that could in turn affect health and health-related behaviors. More research is needed to study how features of neighborhoods differ by or interact with race/ethnicity to influence self-rated oral health. In addition, studies including larger geographic areas and other racial/ethnic groups are needed to confirm these findings.

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