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Neighborhood socioeconomic status and fruit and vegetable intake among Whites, Blacks, and Mexican-Americans in the United States

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Abstract

Background—Socioeconomic and racial/ethnic disparities in health status across the United States are large and persistent. Obesity rates are rising faster in Black and Hispanic populations than in Whites and foreshadow even greater disparities in chronic diseases such as diabetes and cardiovascular disease in years to come. Factors that influence dietary intake of fruits and vegetables in these populations are only partly understood.

Objective—We examined associations between fruit and vegetable intake and neighborhood socioeconomic status (NSES), analyzed whether NSES explains racial differences in intake, and explored the extent to which NSES has differential effects by race/ethnicity of United States (U.S.) adults.

Design—Using geocoded residential addresses from the Third National Health and Nutrition Examination Survey (NHANES III), we merged individual-level data with county and census-tract level U.S. Census data. We estimated three-level hierarchical models predicting fruit and vegetable intake with individual characteristics and an index of neighborhood SES as explanatory variables.

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Results—Neighborhood SES was positively associated with fruit and vegetable intake: a one standard deviation increase in the neighborhood SES index was associated with consumption of nearly 2 additional servings of fruit and vegetables per week. Neighborhood SES explained some of the Black-White disparity in fruit and vegetable intake and was differentially associated with fruit and vegetable intake among Whites, Blacks, and Mexican-Americans.

Conclusions—The positive association of neighborhood SES with fruit and vegetable intake is one important pathway through which the social environment of neighborhoods affects population health and nutrition for Whites, Blacks and Hispanics in the United States.

Keywords

Neighborhood Socioeconomic Status; Race/Ethnicity; Fruit and Vegetable Consumption

Introduction

Socioeconomic and racial/ethnic disparities in health status across the United States are large and persistent and show few signs of decreasing. Multiple studies have linked both individual and neighborhood socioeconomic status to health, but few studies have assessed the pathways through which neighborhood socioeconomic status might affect health.

Diet is an important determinant of obesity and chronic disease. Adequate fruit and vegetable consumption is associated with reduced risk of some of the main causes of mortality in the U.S., including type II diabetes, heart disease, stroke and obesity (1-13). Diets rich in fruits and vegetables are also associated with reduced incidence of several common neoplasms, especially of the respiratory and digestive tract (14). Researchers have found differences in fruit and vegetable intake by race and ethnicity, socioeconomic status, and gender (15-18). Other studies have assessed racial and ethnic differences in additional dimensions of diet, including intake of fat, cholesterol, and fiber (19, 20), as well as in adherence to “healthy diets” (21-25). Understanding the sources of racial and ethnic differences in diet is important in view of the possible contribution of diet to disparities in health outcomes.

The growing literature on the social and built environment and obesity has introduced a strong theoretical foundation for how the neighborhood environment might influence diet. In particular, the socioeconomic characteristics of a neighborhood, also referred to as neighborhood socioeconomic status (NSES), could influence diet through the quantity and quality of food stores and restaurants in the area, which may determine access to nutritious foods; the availability and affordability of fresh produce; and the ease of transportation to grocery stores or healthy food options (26-39). The documented association of NSES and health outcomes such as cardiovascular disease prevalence (40) and mortality (41) lends additional support to the notion that NSES may be associated with diet.

An association of NSES and diet raises two important questions regarding racial and ethnic differences in diet. One question is whether NSES might help to explain these differences, since Blacks and Hispanics generally live in more disadvantaged neighborhoods than Whites. Another is whether NSES might operate differently for different racial and ethnic groups. Numerous scholars have posited that the influence of context on individuals is patterned by race and ethnicity (42, 43). Thus, for example, Blacks who live in affluent neighborhoods may benefit less than similarly placed Whites from the opportunities in those neighborhoods for maintaining healthy diets. (44).

To date, however, limited research has examined the relationship between neighborhood characteristics, including NSES, and diet, and no study has assessed whether neighborhood characteristics explain racial and ethnic differences in diet or whether these characteristics affect different racial and ethnic groups differently. To fill these gaps, we use a geocoded version of the Third National Health and Nutrition Examination Survey (NHANES III) to examine (1) the independent associations between fruit and vegetable intake and NSES, after controlling for individual attributes that may influence diet; (2) whether NSES explains racial differences in fruit and vegetable intake; and (3) the extent to which the associations between fruit and vegetable intake and NSES differ by race and ethnicity. This research builds on a neighborhood deprivation framework that understands socioeconomic characteristics of neighborhoods or residential environments to also share physical (e.g., pollution, nutritious food availability), social (e.g., crime, behavioral norms), and service (e.g., transportation, health care, police protection) environments. These shared environments could influence health and health behaviors (such as diet) above and beyond the health effects of the socioeconomic characteristics of residents living within them (45, 46). Our findings provide additional information that can support the development of policies to improve diet for low income and minority Americans by addressing factors related to dietary intake.

Materials and Methods

Data Source and Study Samples

NHANES III, conducted from 1988 through 1994, is a nationally representative, cross-sectional study of the civilian non-institutionalized population of the U.S. The sampling design oversampled Blacks and Mexican-Americans, and data collection included survey, medical examination, and laboratory components. Overall, 86% of persons recruited for the study were interviewed in their homes, and 77% underwent standardized clinical examinations and additional interviews in a mobile examination center (MEC). The dietary recall segment was conducted by trained interviewers who collected information on all dietary intake within the previous 24-hour period (midnight to midnight) using a computerized interview and coding system. Of the MEC-examined sample, 94% had a complete 24-hour dietary recall.

Consistent with the literature on neighborhood effects, we used census tracts as proxies for neighborhoods (47, 48) and merged the NHANES III with tract-level data from the U.S. Census Bureau using geocoded residential addresses. Approximately 86% of the sample was geocoded to a census tract via a match to an exact address or to a street intersection. The remaining 14% of the sample could only be matched to a zip-code or county centroid; therefore, we excluded these subjects from our analyses due to concerns about the validity of merging tract-level data based on such matches. These subjects were overwhelmingly situated in low-density areas; consequently, our results may not be representative of rural residents.

We further restricted the study samples to adults aged 20 and over and excluded pregnant women, whose diets are likely to be atypical, as well as subjects who had questionable values for dietary intake (greater than 18 servings per day of fruits or vegetables) or who were missing key variables for the analyses (see below). Thus our final study samples consisted of non-pregnant adults who were geocoded to census tracts, had complete fruit or vegetable intake information, and had complete data on other key analytic variables. The sample sizes were 13,310 for the analyses of fruit intake, 13,296 for the analyses of vegetable intake, and 13,281 for the analyses of combined fruit and vegetable intake.

The final study samples comprised about 75.6% of the geocoded NHANES adult sample. Excluded subjects were significantly more likely to be younger, to be U.S.-born, to be non-Hispanic White, to have lower educational attainment and family income, to reside in the

South or Midwest, and to live in poorer neighborhoods with fewer minorities than included subjects. However, there were no significant differences between the two groups of subjects in terms of fruit and vegetable intake or gender.

Measures

The dependent variables in our analyses were number of servings per day of fruit, number of servings per day of vegetables, and combined servings per day of fruits and vegetables, derived from the 24-hour dietary recall.

The individual characteristics used as independent variables included age; gender; race/ethnicity, categorized as non-Hispanic White (hereafter referred to as “White”), non-Hispanic Black (hereafter referred to as “Black”), Mexican-American, or other; nativity, categorized as U.S.-born or foreign-born, educational attainment, categorized as grade school only, some high school, high school graduate, or post high school; family income relative to the federal poverty level (FPL), categorized as poor (< 1 times FPL), low income (1-2 times FPL), middle income (2-4 times FPL), or high income (> 4 times FPL); employment status, categorized as not in the labor force, employed, or unemployed; and region of the U.S., categorized as Northeast, Midwest, South, or West.

We constructed a NSES index at the level of census tracts using six variables obtained from the census. To do this, we first identified 12 theoretically relevant census-tract-level variables and conducted an exploratory factor analysis. Six variables loaded highly on the factor we interpreted as an indicator of socioeconomic status (the loading factor alpha was between 0.80 and 0.93) and thus we selected them to be included in the NSES index. These variables were: (1) percent of adults older than 25 with less than a high school education; (2) percent male unemployment; (3) percent of households with income below the poverty line; (4) percent of households receiving public assistance; (5) percent of households with children that are headed only by a female; and (6) median household income. We then transformed the variables so that higher values corresponded to higher NSES. Second, the six individual items were summed and standardized to create an NSES scale with mean of zero and a standard deviation of one. Thus, an index score greater than zero denotes a tract with SES above the sample average.

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Statistical Analysis

We estimated three-level hierarchical linear models to adjust for the clustering of observations at the tract and county levels, and partitioned the variance of the dependent variables into individual, tract and county components. For each of the three dependent variables, we estimated (1) a model that included only the individual characteristics to investigate the associations between these factors and intake of fruits and vegetables, (2) a model that also included the NSES index, to assess the association between NSES and fruit and vegetable intake as well as the extent to which individual-level associations changed after including NSES, and (3) a model that included the individual characteristics, NSES, and the interaction of NSES and race/ethnicity to test whether the associations between NSES and dietary intake varied by racial/ethnic group. All analyses were weighted using weights that account for the complex sampling design of NHANES III as well as for survey non-response, and a P value of 0.05 or less was chosen as the criterion for statistical significance in all analyses.

We conducted the analyses at the secure Research Data Center of the National Center for Health Statistics (NCHS) in Hyattsville MD, using SAS version 9.1 (SAS Institute, NC). Approval for this study was obtained from the institutional review boards of NCHS and RAND.

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Results

Descriptive Data

Our study sample averaged 1.53 servings of fruit (standard deviation [SD]=2.05), 3.24 servings of vegetables (SD=2.62), and 4.76 servings (SD=3.52) per day of fruits and vegetables combined (Table 1). Whites consumed significantly more combined servings of fruits and vegetables than either Blacks or Mexican-Americans. Specifically, Whites averaged 4.90 servings of fruits and vegetables (SD=3.53) per day, compared with 4.57 (SD=3.40) daily servings for Mexican-Americans and 3.99 (SD=3.38) daily servings for Blacks.

Table 1 also reports unadjusted intra-class correlation coefficients (ICCs) (49), which reflect the proportion of total variance in dietary intake that occurs between tracts within counties (level 2) and between counties (level 3). We found substantial between-tract variation in combined fruit and vegetable intake, fruit intake, and vegetable intake, with unadjusted ICCs of 18.7%, 15.6%, and 16.9%, respectively. Between-county variation in combined fruit and vegetable intake (1.5%) and fruit intake (2.7%) was smaller, and there was no between-county variation in vegetable intake.

About 74.0% of the sample was White, 11.7% was Black, and 5.5% was Mexican American, with the remainder comprising the “Other” category (Table 2). The study sample had a mean age of 44.57 years; additionally, just over half of the participants were women, 12.7% were poor, 23.7% did not graduate from high school, and 15.4% were foreign-born. On average, Whites were older, had higher income, and had higher educational attainment than Blacks and Mexican-Americans. However, Mexican-Americans were much more likely than Whites or Blacks to be foreign-born. About half of all Blacks lived in the South, and more than three-fifths of Mexican-Americans lived in the West.

The NSES index ranged from −7.72 to 1.99, with a mean of zero and standard deviation of 1. As expected, Whites lived in higher SES neighborhoods than Blacks or Mexican-Americans. The NSES index ranged from −3.81 to 1.99 for Whites, with a mean of 0.24 (median of 0.34); from −7.72 to 1.74 for Blacks, with a mean of −1.04 (median of −0.88); and from −6.06 to 1.64 for Mexican-Americans, with a mean of −0.65 (and median of −0.57).

Multivariate Results

In the models that included only individual characteristics as explanatory variables, we found that Blacks consumed 0.42 fewer combined daily servings of fruits and vegetables than Whites (P=0.0003), adjusting for other characteristics, whereas intake of fruit and vegetables was similar for Whites and Mexican-Americans (Table 3). Older age, male gender, foreign birth, higher educational attainment, and higher family income were all associated with higher intake of fruit and vegetables combined. Specifically, men consumed 0.71 more servings of fruits and vegetables per day than women (P<0.0001); U.S.-born individuals consumed 0.85 fewer servings than those who were foreign-born (P<0.0001); individuals who only completed grade school consumed 1.19 fewer servings than those who received education beyond high school (P<0.0001); and individuals in poor families consumed 0.62 fewer servings than those in high-income families (P=0.0009).

Separate analyses of fruit and vegetable intake yielded additional, noteworthy findings (Table 3). Thus Blacks consumed 0.50 fewer daily servings of vegetables than Whites (P<0.0001), but there were no differences across racial/ethnic groups in fruit intake. Men consumed more servings of vegetables than women, but men and women did not significantly differ in fruit intake. In addition, U.S.-born individuals consumed fewer servings of fruit than their foreign-born counterparts, but there was no difference in vegetable consumption by nativity. Otherwise, associations were similar to those in the analyses of fruit and vegetables combined.

Table 3 shows that adjusting for individual-level factors reduced the tract ICCs, but only slightly. Specifically, the tract ICC for combined fruit and vegetable intake was reduced to 17.0%; that for fruit intake was reduced to 14.1%; and that for vegetable intake was reduced to 16.3%. The county ICCs were reduced as well, but these ICCs were small to begin with. Thus geographic variation in dietary intake persisted after adjusting for individual-level factors, especially at the tract level.

When we included the NSES index in the models, we found positive associations between NSES and fruit and vegetable intake (Table 4). A one standard deviation increase in the NSES index was associated with consumption of an additional 0.24 daily servings of fruit and vegetables combined ($P<0.0001$). Moreover, the effect sizes for NSES were similar for fruit and for vegetables when we examined them separately. Thus a one standard deviation increase in the NSES index was associated with consumption of an additional 0.13 servings of fruit per day ($P<0.0001$) and an additional 0.11 servings of vegetables ($P=0.0006$).

Including NSES in the models reduced the Black-White disparity in combined intake of fruit and vegetables that we found in the earlier models that included only individual characteristics as explanatory variables. Specifically, in the model that included NSES, Blacks consumed 0.24 fewer daily servings of fruit and vegetables combined than Whites ($P=0.051$) (Table 4), which corresponds to about half the Black-White gap of 0.42 daily servings found in the earlier analyses (Table 3). Additionally, in the model that included NSES, Blacks consumed 0.16 more daily servings of fruit than Whites ($P=0.025$) (Table 4), whereas there was no difference between Blacks and Whites in fruit intake in the model that included only individual characteristics (Table 3). Including NSES in the models did not substantially alter the Black-White gap in daily servings of vegetables, nor did it have an appreciable impact on the magnitude and statistical significance of the associations of combined fruit and vegetable intake with Mexican-American ethnicity, age, gender, nativity, educational attainment, family income, employment status, or region of residence (compare Tables 4 and 3).

Notably, although NSES was strongly associated with fruit and vegetable intake, including NSES in the models had only a small effect on the tract and county ICCs (compare Tables 4 and 3). Thus NSES did not explain the remaining variance in dietary intake across census tracts.

To assess whether the effects of NSES on fruit and vegetable intake differed across racial/ethnic groups, we estimated models with individual characteristics, NSES, and the interaction of NSES with race/ethnicity. NSES was positively associated with combined fruit and vegetable intake for Whites, Blacks, and Mexican-Americans (Table 5). However, the NSES effect size for Whites (0.35 servings/day for each standard deviation increase in NSES, $P<0.0001$) was roughly twice that for Blacks (0.13, $P=0.0283$) and for Mexican-Americans (0.18, $P=0.0040$). (The NSES effect sizes for the Blacks and Mexican-Americans were significantly different from that for Whites ($P<0.05$), but they were not significantly different from one another.) Separate analyses of fruit and vegetable intake revealed similar patterns in the point estimates—i.e., NSES effect sizes were consistently larger for Whites than for Blacks or Mexican-Americans. However, several of the associations failed to reach statistical significance (Table 5).

Discussion

Dietary intake, particularly fruit and vegetable consumption, is important to health. The findings of this study suggest that the socioeconomic characteristics of neighborhoods influence the intake of fruits and vegetables. Thus effects on diet may be one of the mechanisms through which neighborhood socioeconomic status (NSES) affects health.

Consistent with other studies (50-52), we found that individual characteristics, including gender, nativity, educational attainment, and family income, were related to fruit and vegetable intake. However, our key finding—the observation that merits emphasis—was that NSES exhibited a positive and statistically significant association with fruit and vegetable intake even after controlling for individual characteristics. Further, the coefficients for most individual characteristics did not change appreciably after NSES was included in the models, suggesting that our analyses were able to separate the effects of NSES from those of individual attributes.

Our findings regarding racial and ethnic differences in fruit and vegetable intake, and the extent to which these differences are explained by NSES, are noteworthy. In the analyses that accounted for individual characteristics, but not for NSES, we found that Blacks consumed 0.42 fewer daily servings than Whites of fruits and vegetables combined and 0.50 fewer daily servings of vegetables. When we accounted for NSES, however, we found that nearly half of the Black-White gap in combined intake of fruits and vegetables was explained by NSES. The difference between Blacks and Whites in vegetable intake remained sizable. The analyses also revealed that Blacks consumed more daily servings of fruits than Whites when NSES was taken into account. Thus NSES explained a substantial portion of the Black-White disparity in fruit and vegetable intake. By contrast, fruit and vegetable intake did not differ significantly between Mexican-Americans and Whites irrespective of whether or not the analyses accounted for NSES.

Our findings regarding the interaction between race/ethnicity and NSES suggest that NSES may influence dietary intake differently for different race/ethnic groups. We found a positive and significant association between NSES and combined fruit and vegetable intake for Whites, Blacks, and Mexican-Americans. However, the effect size was much larger for Whites, suggesting that Whites may be better able than Blacks or Mexican-Americans to take advantage of the enhanced opportunities for maintaining a healthy diet in more affluent neighborhoods. Another possibility is that strong cultural influences on the diets of Blacks and Mexican-Americans make them less susceptible than Whites to the effects of environmental factors (53, 54).

Because the racial composition of neighborhoods is highly correlated with NSES, we were concerned that our findings for NSES might in part reflect associations of fruit and vegetable intake with neighborhood racial composition. (In our data, $r=0.75$ for the correlation between NSES and percent minority across census tracts.) To address this concern, we estimated additional models that included both NSES and the percent minority in the census tract. We found that only NSES was significant in the model for intake of fruit and vegetable combined ($P<0.0001$) and in the model for fruit intake ($P<0.0001$), and that the NSES effect sizes were virtually unchanged in these models compared with the models that did not include neighborhood racial composition. The NSES effect size was slightly reduced in the model for vegetable intake when we included percent minority, but NSES remained nearly significant ($P=0.0592$) in the expanded model, whereas percent minority did not approach significance. These findings suggest that neighborhood racial composition was not an important omitted confounder in our analyses.

Several limitations of our study deserve mention. First, our findings regarding the extent to which NSES explains racial and ethnic disparities in fruit and vegetable consumption should be interpreted with caution owing to the degree of racial and economic segregation in the data. Whites tend to live in higher SES neighborhoods than Blacks and Mexican-Americans, consequently, the overlap in the distributions of NSES across racial and ethnic groups was limited, especially at the lower end of the distributions.

Second, potential selection processes that sort individuals into neighborhoods are a challenge for observational neighborhood studies, and may limit our ability to draw causal inferences. In particular, there may be unmeasured factors that are correlated with both people's concern about their diets—or about their health—and their choice of neighborhood.

Third, research on neighborhoods is limited by the need to operationalize such a complex conceptual construct regarding geographic spaces. At the national level, in particular, it is difficult to define neighborhoods that are meaningful from place to place using pre-established geographic boundaries. Nonetheless, census tracts, although imperfect proxies for neighborhoods, have been used in the vast majority of neighborhood studies (47, 48). Useful properties of census tracts include relative consistency of population size across tracts and relative homogeneity of the population within tracts.

Finally, the dietary data in NHANES is based on just one recall over a 24-hour period. A single 24-hour dietary recall is unlikely to be representative of usual individual intake, as day-to-day intake is highly variable for many individuals (55). However, a single 24-hour recall is adequate for estimates of group means (56). Moreover, measurement error introduced by the use of a single 24-hour recall is likely to reduce the precision of estimated effect sizes in multivariate analyses—and hence the ability to detect significant associations—but is not expected to bias the point estimates.

From a policy perspective, understanding the associations between neighborhood SES and health behaviors, such as diet, is one important step towards improving overall health status. Our finding that NSES was positively associated with fruit and vegetable intake suggests that special efforts—whether by community groups, business, or government—to increase the availability of fresh produce and other healthy foods in disadvantaged neighborhoods may help local residents improve their diets and are likely to be warranted. Additionally, our finding that NSES mattered less for Blacks and Mexican-Americans than for Whites suggests that these groups may respond differently to the availability of healthy food options. Additional research is needed to investigate the mechanisms underlying this finding as well as their implications for policy.

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Table 1

Weighted Descriptive Analyses of the Dependent Variables[1,2]

	FULL SAMPLE	MEXICAN-AMERICANS	NH BLACK	NH WHITE
Servings/Day of Fruit, n=13,310 (Mean, SD)	1.53 (2.05)	1.52(0.92)	1.30(1.26)	1.55(2.86)
ICC-Level 2 (%)	15.6	N/A	N/A	N/A
ICC-Level 3 (%)	2.7			
Servings/Day of Vegetables, n=13,296 (Mean, SD)	3.24 (2.62)	3.05(1.07)	2.69(1.61)	3.35(3.69)
ICC-Level 2 (%)	16.9	N/A	N/A	N/A
ICC-Level 3 (%)	0.5[3]			
Combined Servings/Day of Fruit and Vegetables, n=13,281 (Mean, SD)	4.76 (3.52)	4.57 (3.40)	3.99 (3.38)	4.90 (3.53)
ICC-Level 2 (%)	18.7	N/A	N/A	N/A
ICC-Level 3 (%)	1.5			

[1]Racial/Ethnic differences in group means are significant at P<0.05 (PROC TTEST) with the exception of Mexican-American fruit intake relative to that of Whites. SD=standard deviation.

[2]ICCs = intra-class correlation coefficients, which provide an estimate of the proportion of total variance in dietary outcome that occurs between tracts within counties (level 2) and between counties (level 3). Unconditional hierarchical linear models (HLM), i.e. models with no independent variables, were estimated with PROC MIXED using SAS version 9.1 in order to derive unadjusted ICCs.

[3]There is no significant clustering of observations at the county level for vegetable intake.

Table 2

Weighted Characteristics of the Study Sample[1]

	FULL SAMPLE	MEXICAN-AMERICANS	NH BLACK	NH WHITE
n	**13,281**	**3,827**	**3, 819**	**5,036**
Race/Ethnicity (%)				
Mexican American	5.5			
Non-Hispanic (NH) Black	11.7	N/A	N/A	N/A
‘Other’	8.8			
Non-Hispanic (NH) White	74.0			
Age (Mean, SD)	44.57 (17.16)	37.69 (14.39)	41.93 (16.18)	45.91 (17.49)
Female (%)	52.2	46.3	55.3	52.1
Nativity (%)				
U.S.-born	84.6	44.1	93.0	94.1
Foreign-born	15.4	55.9	7.0	5.9
Educational Attainment (%)				
Grade School	10.9	41.1	12.2	6.9
Some High School	12.8	17.4	19.0	11.5
High School	32.3	23.5	37.7	33.1
Post High School	44.0	17.9	31.2	48.6
Family Income (%)				
Poor	12.7	35.8	28.5	7.3
Low income	20.4	32.6	28.8	17.2
Middle income	38.9	23.2	31.0	41.2
High income	28.1	8.4	11.7	34.3
Employment Status (%)				
Employed	66.2	65.2	61.5	67.5
Not in labor force	28.4	27.2	30.5	28.2
Unemployed	5.5	7.7	8.0	4.4
Region (%)				
Northeast	21.9	1.4	17.7	23.4
Midwest	23.6	10.5	21.0	26.5
South	30.3	24.8	50.8	28.2
West	24.2	63.2	10.5	22.0
Neighborhood SES Index (Mean, SD)	0 (1.0)	−0.65 (0.45)	−1.04 (0.85)	0.24 (1.09)
Range	−7.72, 1.99	−6.06, 1.64	−7.72, 1.74	−3.81, 1.99

[1]For all variables, race/ethnic differences are significant at $P<0.05$ (Pearson's chi-square test for categorical variables and t-tests for continuous variables). SD=standard deviation.

Table 3

Regression Coefficients (Fixed Effects), Random Effects, and P-values From Multivariate HLM Models That Include Only Individual-Level Characteristics As Explanatory Variables For Fruit/Vegetable Intake, Using the Third National Health and Nutrition Examination Survey 1988-1994 (NHANES III) [1]

	Servings of Fruit and Vegetables Combined (N=13,281)		Servings of Fruit (N=13,310)		Servings of Vegetables (N=13,296	
	Coeff	**P-value**	**Coeff**	**P-value**	**Coeff**	**P-value**
Race/Ethnicity						
Mexican American	0.004	0.9783	0.15	0.1609	-0.16	0.1364
NH Black	**-0.42**	**0.0003**	0.06	0.3763	**-0.50**	**<0.0001**
‘Other’	-0.30	0.1756	-0.22	0.1609	-0.07	0.6302
NH White (ref)	---	---	---	---	---	---
Age (centered)	**0.03**	**<0.0001**	**0.02**	**<0.0001**	**0.01**	**0.0122**
Age (centered) squared	-0.0001	0.3297	0.0001	0.1181	**-0.0003**	**0.0082**
Female	**-0.71**	**<0.0001**	-0.09	0.0944	**-0.62**	**<0.0001**
US-born	**-0.85**	**<0.0001**	**-0.63**	**<0.0001**	-0.21	0.0634
Educational Attainment						
Grade School	**-1.19**	**<0.0001**	**-0.70**	**<0.0001**	**-0.51**	**<0.0001**
Some High School	**-0.81**	**<0.0001**	**-0.55**	**<0.0001**	**-0.27**	**0.0284**
High School	**-0.48**	**<0.0001**	**-0.40**	**<0.0001**	-0.08	0.3563
Post High School (ref)	---	---	---	---	---	---
Family Income						
Poor	**-0.62**	**0.0009**	**-0.26**	**0.0361**	**-0.35**	**0.0070**
Low income	**-0.41**	**0.0158**	-0.18	0.0600	-0.23	0.0692
Middle income	**-0.31**	**0.0186**	-0.09	0.3374	**-0.22**	**0.0203**
High income (ref)	---	---	---	---	---	---
Employment status						
Employed	0.23	0.2198	0.06	0.4828	0.18	0.2842
Not in Labor Force	0.27	0.1457	0.08	0.2585	0.18	0.2674

	Servings of Fruit and Vegetables Combined (N=13,281)		Servings of Fruit (N=13,310)		Servings of Vegetables (N=13,296	
	Coeff	P-value	Coeff	P-value	Coeff	P-value
Unemployed (ref)	---	---	---	---	---	---
Region						
Northeast	0.12	0.5865	0.06	0.6639	0.06	0.6651
Midwest	0.01	0.9514	0.04	0.7614	-0.02	0.9040
South	-0.27	0.1407	**-0.26**	**0.0144**	-0.01	0.9512
West (ref)	---	---	---	---		
Intercept	6.44	<0.0001	2.44 <	0.0001	4.01	<0.0001
Random Effects						
Level 1 variance	**9.63**	**<0.0001**	**3.32**	**<0.0001**	**5.58**	**<0.0001**
Level 2 variance	**1.99**	**<0.0001**	**0.55**	**<0.0001**	**1.09**	**<0.0001**
Level 3 variance	**0.09**	**0.0309**	**0.05**	**0.0026**	0.03	0.0723
ICC-level 2 (%) [2]	**17.03**		**14.06**		**16.28**	
ICC- level 3 (%) [2]	**0.74**		**1.36**		0.46	
Fit Statistics						
-2 Res LL	77895.8		63767.9		70686.1	
AIC	77901.8		63773.9		70692.1	

[1] Hierarchical linear models (HLM), or multi-level regressions, were conducted with PROC MIXED using SAS version 9.1. Level 1=individual level, level 2= tract level within counties, and level 3=county level.

[2] ICCs = intra-class correlation coefficients, which provide an estimate of the proportion of total variance in dietary outcome that occurs between geographic areas. Level 2 ICCs provide an estimate of the proportion of variance in dietary outcome that occurs between tracts within counties while level 3 ICCs provide an estimate of the proportion of variance in dietary outcome that occurs between counties.

Table 4

Regression Coefficients (Fixed Effects), Random Effects, and P-values From Multivariate HLM Models That Include Neighborhood SES in Addition to Individual Characteristics As Explanatory Variables For Fruit/Vegetable Intake, Using the Third National Health and Nutrition Examination Survey 1988-1994 (NHANES III) [1]

	Servings of Fruit and Vegetables Combined (n=13,281)		**Servings of Fruit (n=13,310)**		**Servings of Vegetables (n=13,296)**	
	Coeff	**P-value**	**Coeff**	**P-value**	**Coeff**	**P-value**
Neighborhood SES	**0.24**	**<0.0001**	**0.13**	**<0.0001**	**0.11**	**0.0006**
Race/Ethnicity						
Mexican American	0.11	0.4986	0.21	0.0578	-0.12	0.2951
NH Black	-0.24	0.0509	**0.16**	**0.0245**	**-0.41**	**<0.0001**
'Other'	-0.24	0.2870	-0.19	0.2398	-0.04	0.7659
NH White (ref)	---	---	---	---	---	---
Age (centered)	**0.02**	**<0.0001**	**0.02**	**<0.0001**	**0.01**	**0.0146**
Age (centered) squared	-0.0001	0.3277	0.0001	0.1146	**-0.0003**	**0.0081**
Female	**-0.71**	**<0.0001**	-0.09	0.0945	**-0.62**	**<0.0001**
US-born	**-0.83**	**<0.0001**	**-0.62**	**<0.0001**	-0.21	0.0757
Educational Attainment						
Grade School	**-1.14**	**<0.0001**	**-0.66**	**<0.0001**	**-0.48**	**0.0002**
Some High School	**-0.77**	**<0.0001**	**-0.53**	**<0.0001**	**-0.25**	**0.0423**
High School	**-0.46**	**<0.0001**	**-0.39**	**<0.0001**	-0.07	0.4194
Post High School (ref)	---	---	---	---	---	---
Family Income						
Poor	**-0.52**	**0.0074**	-0.21	0.1103	**-0.30**	**0.0228**
Low income	**-0.34**	**0.0468**	-0.14	0.1432	-0.20	0.1201
Middle income	**-0.27**	**0.0341**	-0.07	0.4318	**-0.20**	**0.0314**
High income (ref)	---	---	---	---	---	---
Employment status						
Employed	0.23	0.2277	0.06	0.5065	0.17	0.2907

	Servings of Fruit and Vegetables Combined (n=13,281)		Servings of Fruit (n=13,310)		Servings of Vegetables (n=13,296)	
	Coeff	**P-value**	**Coeff**	**P-value**	**Coeff**	**P-value**
Not in Labor Force	0.27	0.1346	0.09	0.2414	0.19	0.2600
Unemployed (ref)	---	---	---	---	---	---
Region						
Northeast	0.14	0.4948	0.07	0.5734	0.07	0.6037
Midwest	0.02	0.9021	0.04	0.7179	-0.01	0.9477
South	-0.27	0.1327	**-0.26**	**0.0103**	-0.01	0.9448
West (ref)	---	---	---	---	---	---
Intercept	6.37	<0.0001	2.39	<0.0001	3.97	<0.0001
Random Effects						
Level 1 variance	**9.62**	**<0.0001**	**3.32**	**<0.0001**	**5.58**	**<0.0001**
Level 2 variance	**1.97**	**<0.0001**	**0.55**	**<0.0001**	**1.09**	**<0.0001**
Level 3 variance	**0.07**	**0.0490**	**0.04**	**0.0053**	0.03	0.0717
ICC-level 2 (%) [2]	**16.90**		**13.95**		**16.23**	
ICC-level 3 (%) [2]	**0.58**		**1.14**		0.44	
Fit Statistics						
-2 Res LL	77876.0		63752.7		70682.3	
AIC	77882.0		63758.7		70688.3	

[1] Hierarchical linear models (HLM), or multi-level regressions, were conducted with PROC MIXED using SAS version 9.1. Level 1=individual level, level 2= tract level within counties, and level 3=county level.

[2] ICCs = intra-class correlation coefficients, which provide an estimate of the proportion of total variance in dietary outcome that occurs between geographic areas. Level 2 ICCs provide an estimate of the proportion of variance in dietary outcome that occurs between tracts within counties while level 3 ICCs provide an estimate of the proportion of variance in dietary outcome that occurs between counties.

Table 5

Regression Coefficients (Fixed Effects), Random Effects, and P-values From Multivariate HLM Models That Include Individual-level Characteristics and Neighborhood SES As Explanatory Variables For Fruit/Vegetable Intake and Test the Interaction of Race/Ethnicity with Neighborhood SES, Using the Third National Health and Nutrition Examination Survey 1988-1994 (NHANES III) [1]

	Servings of Fruit and Vegetables Combined[3] (n=13,281)		**Servings of Fruit (n=13,310)**		**Servings of Vegetables (n=13,296)**	
NSES Effect by Race/Ethnicity[2]	**Coeff**	**P-value**	**Coeff**	**P-value**	**Coeff**	**P-value**
NSES for Mexican Am	**0.18**	**0.0040**	**0.08**	**0.0346**	0.09	0.0878
NSES for NH Black	**0.13**	**0.0283**	**0.08**	**0.0423**	0.05	0.2334
NSES for 'Other'	**0.35**	**0.0485**	0.12	0.2311	0.23	0.1054
NSES for NH White	**0.35**	**<0.0001**	**0.19**	**0.0004**	**0.14**	**0.0198**
Random Effects						
Level 1 variance	**9.62**	**<0.0001**	**3.32**	**<0.0001**	**5.58**	**<0.0001**
Level 2 variance	**1.98**	**<0.0001**	**0.55**	**<0.0001**	**1.09**	**<0.0001**
Level 3 variance	0.06	0.0599	**0.04**	**0.0072**	0.03	0.0704
ICC-level 2 (%) [4]	**16.96**		**13.95**		**16.28**	
ICC-level 3 (%) [4]	**0.53**		**1.06**		0.44	
Fit Statistics						
-2 Res LL	77877.0		63759.1		70687.7	
AIC	77883.0		63765.1		70693.7	

[1] Hierarchical linear models (HLM), or multi-level regressions, were conducted with PROC MIXED using SAS version 9.1. Level 1=individual level, level 2= tract level within counties, and level 3=county level. All models are adjusted for age, age-squared, gender, nativity, educational attainment, family income, employment status, and region of residence and include race/ethnicity, NSES, and NSES*race/ethnicity. Complete results are available from the authors.

[2] We used the Estimate statement within PROC MIXED models to directly estimate the effect of NSES for each racial/ethnic group (NSES+NSES*Race/Ethnicity) and test whether each effect is significantly different from zero.

[3] The effect of NSES on combined fruit and vegetable intake for Whites is significantly different from that for Mexican-Americans (P=0.03) and Blacks (P=0.01). There was no significant difference relative to Whites in the effect of NSES on fruit intake or vegetable intake for Mexican-Americans or Blacks. Furthermore, there was no significant difference between Blacks and Mexican-Americans in the effect of NSES on any of the dietary outcomes.

[4] ICCs = intra-class correlation coefficients, which provide an estimate of the proportion of total variance in dietary outcome that occurs between geographic areas. Level 2 ICCs provide an estimate of the proportion of variance in dietary outcome that occurs between tracts within counties while level 3 ICCs provide an estimate of the proportion of variance in dietary outcome that occurs between counties.