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Neighborhood socioeconomic status in relation to 10-year weight gain in the Black Women's Health Study

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Abstract

Background—Lower individual socioeconomic status (SES) is a predictor of obesity in developed countries. In cross-sectional studies, low neighborhood SES has also been positively associated with body mass index (BMI). We prospectively assessed the association of neighborhood SES with 10 year change in weight and with the incidence of obesity among 48,359 women in the Black Women's Health Study, a follow-up study of U.S. black women aged 21–69 years at baseline in 1995.

Methods—We used factor analysis to create an index of neighborhood SES score based on 6 census variables. We used mixed linear regression models to calculate the multivariable adjusted least-squares means for changes in body weight, and Cox regression models to derive incidence rate ratios (IRR) and 95% confidence intervals (CI), across quintiles of neighborhood SES.

Results—Ten-year weight gain was positively associated with lower neighborhood SES score, after adjustment for individual SES and behavioral variables such as physical activity and caloric intake. Among women of normal weight at baseline (BMI<25 kg/m^2), the incidence of becoming obese increased as neighborhood SES decreased (multivariable incidence rate ratio in the lowest compared to the highest SES neighborhood =1.32, 95% CI 1.10, 1.59). The associations of neighborhood SES with weight gain and obesity incidence were most evident among BWHS participants who had graduated from college.

Conclusions—These prospective data suggest that lower neighborhood SES contributes to overweight and obesity in African American women.

Keywords

body weight changes; BMI; socioeconomic status; neighborhoods

Low individual socioeconomic status (SES) is a predictor of obesity in developed countries and this relation is particularly marked in women.[1,2] The most consistent evidence comes

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from cross-sectional studies, but some longitudinal studies have also indicated a similar association.[3] In the United States, the prevalence of overweight and obesity (body mass index (BMI)≥30 kg/m^2) is considerably higher among black women than white women. In National Health and Nutrition Examination Survey (NHANES) data from 2003–2004, 82% of black women were overweight or obese (BMI ≥25), 54% were obese (30≤BMI<40), and 15% were severely obese (BMI ≥40); comparable figures for white women were 58%, 30%, and 6%.[4]. The racial disparity exists at all levels of individual education and income.[5,6]

There is some evidence that low neighborhood SES is also associated with obesity and may contribute, therefore, to the racial disparity in BMI. Due in part to racial segregation in housing, black women at all levels of individual SES tend to live in more disadvantaged neighborhoods than their white counterparts.[7] In studies from Europe[8–10] and the United States[5,11–13], neighborhood SES was inversely associated with BMI and obesity, independent of individual SES. Most previous studies have been cross-sectional and the results may reflect selection bias, wherein people with high BMI tend to live in neighborhoods of low SES. There has been only one longitudinal study of neighborhood SES and weight gain: in data from the Atherosclerosis Risk in Communities study there was no significant relation between neighborhood SES and 5-year weight gain in either black or white women.[12]

Disadvantaged neighborhoods have limited access to healthy foods[14] and exercise facilities[15] so that residents may have difficulty achieving a healthful energy balance. Such neighborhoods are also sources of chronic stress due to poor quality housing, crowding, and high crime rate[16], and stress has been shown to influence the accumulation of body fat.[17–19]

In the present paper, we assess the influence of neighborhood SES on weight change and incident obesity over 10 years of follow-up in the Black Women's Health Study (BWHS), a nationwide cohort study of 59,000 African-American women. BWHS participants live in a range of neighborhoods from disadvantaged to wealthy and almost half are college graduates.

METHODS

The study population

The BWHS is a prospective cohort study established in 1995, when approximately 59,000 African-American women aged 21 through 69 years were recruited via postal questionnaire from among subscribers to Essence magazine, members of selected black women's professional organizations, and friends and relatives of early respondents.[20] The baseline questionnaire elicited information on demographic and lifestyle factors, reproductive history, height and weight, dietary intake, and medical conditions. The cohort is followed biennially by mailed questionnaire. The study protocol was approved by the Institutional Review Board of Boston University and participants indicate their consent by completing and returning the questionnaires. At baseline, the median age was 38. Participants were from across the U.S: Northeast, 28%; South, 30%; Midwest, 23%, and West, 19%. Ninety-seven percent of the cohort had completed high school or a higher level of education, with 36% having some college and 44% having completed college. Through the 2005 follow-up cycle, follow-up of the baseline-line cohort has averaged over 80%.

This analysis used data from the baseline questionnaire and 5 subsequent follow-up cycles covering the time period 1995 through 2005. Of 58,616 women who completed the baseline questionnaire and returned at least one follow-up questionnaire, we excluded women who were missing weight at baseline (n=792) or on all follow-up questionnaires (n=252);

reported a weight of greater than 350 pounds at baseline (n=118); reported bariatric surgery (n=103); were pregnant at baseline (n=1015); reported a prevalent cancer at baseline (n=1185) or incident cancer over follow-up (n=1690); or were missing census data because the address could not be geocoded (n=5102).

Neighborhood SES

Information on participants' neighborhood of residence was obtained from the 2000 US census, with census block groups used as proxies for residential neighborhoods. Census block groups are subdivisions of census tracts that generally average approximately 1500 people.[21] BWHS residences, as reported on questionnaires from 1995 to 2003, were linked to the appropriate census block groups. The geocoding was carried out by a commercial firm that has been shown to geocode accurately.[22]

Using principal components analysis with a varimax rotation, we conducted a factor analysis of 29 block group census variables measuring dimensions of education, income, and wealth, from which we selected 6 variables to represent neighborhood SES.[23,24] The variables selected were median household income; median housing value; percent of households receiving interest, dividend or net rental income; percent of adults aged ≥25 years that have completed college; percent of employed persons aged ≥16 years that are in occupations classified as managerial, executive, or professional specialty; and percent of families with children that are not headed by single female. Regression coefficients from the factor analysis were used to weight the variables that contributed to a combined neighborhood SES score.[24] The score was divided into quintiles, with the lowest quintile representing lowest neighborhood SES and the highest quintile representing highest neighborhood SES.

Weight and change in weight

Data on height and weight were obtained at baseline and weight was updated on each subsequent follow-up questionnaire. In a validation study conducted among 115 participants, the mean of self-reported weight was 176 pounds and the mean of technician-measured weight was 181 pounds. For height, the self-reported and technician-measured mean values were 64.4 inches and 64.0 inches, respectively. The Spearman correlation coefficients between self-reported and measured weight and height at baseline were, respectively, 0.97 ($p<0.001$) and 0.93 ($p<0.001$).[25] For women who were currently pregnant or were missing weight in a questionnaire cycle, we interpolated weight as the average of the previous and next reported weight. We calculated BMI at each cycle as weight in kilograms/height in meters squared. We calculated weight change for each two-year interval from information provided from 1995 through 2005; for example, weight change for the 1997–1999 follow-up interval was the difference between weights reported in 1997 and 1999 in kilograms (converted from pounds).

Covariates

Data on smoking status, alcohol consumption, vigorous physical activity, and walking for exercise were collected at baseline and updated on each follow-up questionnaire. Information on household size and family income was collected on the 2003 follow-up questionnaire. Marital status and years of education were obtained in 1995. Modified versions of the short Block-NCI food frequency questionnaire[26] were included in the 1995 and 2001 surveys; from these we obtained measures of total daily energy intake (in kilocalories) and percent of calories from fat (in grams).

Statistical analysis

We used mixed linear regression models to calculate the multivariable adjusted least-squares means for changes in body weight across quintiles of neighborhood SES. These models accounted for within-person correlation of weight over each 2-year cycle. Continuous covariates were set to their respective median values and categorical covariates were set to their modal values. Regression coefficients, representing the mean weight change in each 2-year interval, were multiplied by 5 to obtain mean weight change over the 10-year follow-up period. In an initial model (model 1), we adjusted for age (continuous) and calendar time. The final model (model 2) added years of education (≤12, 13–15, 16, ≥17), family income (≤$25,000, $25,001–$50,000, $50,001–$100,000, >$100,000), number of persons in the household (1, 2, 3, 4, ≥5), marital status (married, divorced/widowed/separated, single), number of cigarettes smoked per day (nonsmoker, <15, 15–24, ≥25), number of drinks per day (<1, 1–6, 7–13, ≥14), vigorous exercise (hours/week) (0, <1, 1–2, 3–4, 5–6, ≥7), walk for exercise (hours/week) (0, <1, 1–2, 3–4, 5–6, ≥7), quintiles of energy intake (kcal/day), and quintiles of percentage of calories from fat. Missing values were modeled as a separate category.

For the analysis of incidence of obesity, we restricted the analytic cohort to women with BMI<25 at baseline. Participants were classified as incident cases of obesity if they attained a BMI of ≥30 during follow-up; the year of onset was assigned as the midpoint of the two-year cycle of the questionnaire in which it was reported. Each participant contributed person-time from baseline in 1995 until the occurrence of obesity, death, loss to follow-up, or end of follow-up, whichever came first. We used Cox regression models to derive incidence rate ratios (IRR) and 95% confidence intervals (CI) for the relation of neighborhood SES to obesity incidence, accounting for within-block group correlation. Model 1 adjusted for age and calendar time; model 2 added the same variables as in the final model for the weight change analysis. All nalyses were performed using SAS version 9.1 (SAS Institute, Cary, NC).

RESULTS

Baseline characteristics of all participants and of women with BMI<25 at baseline are shown in table 1 by quintile of neighborhood SES. Relative to women in higher SES neighborhoods, participants who lived in low SES neighborhoods at baseline had a higher BMI, higher total energy intake, higher percent calorie intake from fats, lower family income, fewer years of education, smoked more, drank more, and were more likely to be single and sedentary.

Weight gain was inversely related to quintile of neighborhood score, with a statistically significant test of linear trend (table 2). In model 1, which adjusted only for age and questionnaire cycle, mean weight gain for women in the lowest SES neighborhoods was 6.79 kg compared to 6.24 kg for women in the highest SES neighborhoods. Results were similar in the multivariable model which controlled for individual SES factors and behavioral variables: the difference in weight gain between the two extreme quintiles was 0.59 kg (a 9% increase).

We assessed the incidence of obesity over ten years of follow-up among women with BMI<25 at baseline by quintile of neighborhood SES score (Table 3). In models adjusted for age and calendar time (model 1), the IRRs increased with decreasing neighborhood SES (p for trend<0.001); the IRR for the lowest quintile of SES compared to the highest was 1.55 (95% CI 1.30,1.83). With additional adjustment for individual SES and behavioral variables (model 2), the association persisted, although the magnitude of the association was attenuated (IRR for lowest compared to highest SES neighborhoods = 1.32, 95% CI 1.10, 1.59).

We calculated mean 10-year weight change and IRRs for obesity within strata of years of education (table 4). There was no association between weight gain and neighborhood SES among those with ≤12 years of education. Among those with 13–15 years of education, there was an inverse association but it was not statistically significant. Among those with ≥16 years of education, the difference in 10-year weight gain between the lowest and highest quintiles of SES was 0.80 kg, and the trend was significant. Similarly, IRRs for obesity were elevated in the lower quintiles compared to the highest quintile of SES for those with 13–15 and ≥16 years of education, but not among those with ≤12 years, and the trend was significant only in the most highly educated group.

DISCUSSION

Ours is the first large-scale prospective study of the influence of neighborhood characteristics on weight gain among African American women. The findings, based on approximately 48,000 African American women followed for 10 years, indicate that both weight gain and incidence of obesity were inversely associated with the socioeconomic level of the neighborhoods in which women resided, above and beyond the effects of individual SES and behavioral factors such as physical activity and caloric intake. The associations with neighborhood SES were most apparent among the most well educated women.

A longitudinal analysis carried out in the Atherosclerosis Risk in Communities study used a factor score based on 6 US census variables that included 5 of the 6 variables in our score. Contrary to our findings, mean 5-year weight gain was greatest among African American women in the highest SES neighborhoods. A possible explanation for the different findings lies in the characteristics of the study participants. In the Atherosclerosis Risk in Communities study, 40% of the black women had not completed high school[12], compared with 3% of BWHS participants. These are the women who have the least favorable health behaviors (e.g. poor diet, sedentary)[27,28] and may therefore be least affected by neighborhood characteristics. In the present study, low neighborhood SES was not associated with increased weight gain among the subgroup of women who had completed 12 or fewer years of education.

As noted in the introduction, cross-sectional studies have found positive associations of obesity with low neighborhood SES.[5,11–13] Only the report from NHANES (which included 3203 black men and women) presented race- and sex-specific analyses.[13] In that study, black women who lived in neighborhoods characterized as the most deprived had higher levels of BMI than those in less deprived neighborhoods, independent of individual education and family income.[13] No U.S. studies have assessed the association within strata of education.

A potential biologic mechanism linking BMI and neighborhood SES may be stress. Neighborhoods of low SES are sources of chronic stress due to limited access to resources like high-quality housing and health care, high crime rates and perceived threats of crime, more refused services (e.g., taxi, credit), and greater crowding and exposure to noise.[16] Stress can result in neuroendocrine-autonomic dysregulation which in turn can influence the accumulation of excess body fat.[17–19] Stress activates the central sympathetic nervous system and the hypothalamic-pituitary-adrenal (HPA) axis which, via corticotrophin-releasing hormone, stimulates adrenocorticotropic hormone production and thereby cortisol secretions.[29] Cortisol activates lipoprotein lipase, which regulates lipid accumulation in adipocytes, increasing fat retention.[17,18] Nonbiologic mechanisms include limited access in disadvantaged neighborhoods to healthy foods[14] and exercise facilities.[15]

Follow-up studies such as our own improve upon cross-sectional studies by assessing the relation of neighborhood SES to weight change and obesity incidence over time. In cross-sectional studies, some portion of associations observed between neighborhood characteristics and BMI may be due to selection bias, wherein overweight and obese people are preferentially selected into neighborhoods of low SES due to lack of choices in residential location.

A validation study indicated that reporting of weight by BWHS participants was accurate.[25] Errors in reporting weight, if nondifferential, would have diluted associations. We were able to control for important potential confounding variables, including physical activity, caloric intake, cigarette smoking, and individual level of SES.

A study limitation is that we assessed only those neighborhood factors thought to characterize socioeconomic aspects of a residential neighborhood. We were not able to assess other neighborhood factors such as psychosocial hazards[11], the built environment[30], or food sources.[31]

The large size of the BWHS and the substantial number of well-educated African American women participants allowed for informative analyses of the modifying effect of education on the association of neighborhood SES with weight gain and obesity. Our results indicate that well educated African American women who live in disadvantaged neighborhoods have greater weight gain and are more likely to develop obesity than African American women of the same educational levels who live in more affluent neighborhoods. Thus, neighborhood SES may contribute to the black-white disparity in obesity, given that far more well-educated black women live in disadvantaged neighborhoods than do similarly-educated white women.[7] Our findings contribute to the growing body of evidence that implicates aspects of neighborhood as causes of adverse health outcomes, and as contributing to population disparities in health.[32–34]

What is already known on this subject

Studies from the U.S. and Europe show that women living in neighborhoods of low socioeconomic status (SES) have higher body mass indices (BMI) than do women living in neighborhoods of higher SES, regardless of individual SES. Most previous studies have been cross-sectional and results may reflect residential selection bias. Prospective data on the relation between neighborhood SES and BMI and weight change are needed, particularly among African-American women among whom the prevalence of overweight and obesity is high and who, regardless of their individual SES, are more likely to live in disadvantaged neighborhoods than are white women.

What this study adds

Among 48,000 African American women followed for 10 years, both weight gain and incidence of obesity were inversely associated with the SES of the neighborhoods in which the women resided, above and beyond the effects of individual SES, physical activity, and caloric intake. Our findings suggest that living in neighborhoods of lower SES contributes to overweight and obesity in African American women.

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Table 1

Baseline Characteristics by Quintile of Neighborhood SES, BWHS 1995

Neighborhood SES	Quintile 1 (lowest)	Quintile 2	Quintile 3	Quintile 4	Quintile 5 (highest)
All participants (N=48,359)					
Mean of characteristic					
Age (years)	38.9	38.7	38.5	38.3	39.3
BMI	29.3	28.5	27.7	27.4	26.5
Energy intake (kcal)	1663	1605	1562	1534	1518
% energy from fat	34.2	33.5	33.2	32.8	32.0
% of participants with characteristic					
Obese	38.5	33.3	28.7	26.5	21.0
Education (≥16 years)	28.7	38.4	46.0	52.5	65.1
Family income (≥$ 100,000)	3.7	7.0	10.9	15.4	27.0
Marital status: single	38.7	36.0	34.8	32.8	31.1
No vigorous activity	38.8	34.9	31.3	27.3	24.8
No walking for exercise	20.5	19.2	18.2	16.8	15.4
Cigarettes per day (≥15)	13.5	12.1	11.4	11.4	10.9
Drinks per week (≥7)	6.9	5.9	5.5	4.6	5.5
Participants with BMI<25 at baseline (N=18.777)					
Mean of characteristic					
Age (years)	35.5	35.8	35.6	35.9	37.1
BMI	22.2	22.2	22.3	22.2	22.1
Energy intake (kcal)	1597	1534	1488	1443	1456
% energy from fat	34.0	32.9	32.9	32.1	31.4
% of participants with characteristic					
Education (≥16 years)	34.2	44.8	51.2	59.4	71.5
Family income (≥$ 100,000)	5.8	10.0	14.5	20.4	30.8
Marital status: single	46.3	41.5	40.8	39.2	35.4
No vigorous activity	31.3	28.1	23.3	21.7	18.8
No walking for exercise	23.0	21.2	19.8	18.7	17.2
Cigarettes per day (≥15)	11.3	9.4	8.4	8.5	8.4

Neighborhood SES	Quintile 1 (lowest)	Quintile 2	Quintile 3	Quintile 4	Quintile 5 (highest)
Drinks per week (≥7)	7.0	5.1	5.0	4.8	5.4

BMI, body mass index; BWHS, Black Women's Health Study; SES, socioeconomic status

Table 2

Mean 10 Year Weight Change (kgs) by Neighborhood SES, BWHS 1995–2005

	Mean weight change (kgs) (95% CI)	
Neighborhood SES	**Model 1***	**Model 2†**
Quintile 1 (lowest)	6.79 (6.54,7.04)	6.85 (6.59,7.10)
Quintile 2	6.93 (6.68,7.71)	6.89 (6.64,7.14)
Quintile 3	6.83 (6.61,7.06)	6.77 (6.55,7.00)
Quintile 4	6.70 (6.48,6.92)	6.66 (6.44,6.88)
Quintile 5 (highest)	6.24 (6.05, 6.44)	6.26 (6.05,6.48)
	$P_{trend}<0.001$	$P_{trend}<0.001$

BWHS, Black Women's Health Study; CI, confidence interval; SES, socioeconomic status

*Adjusted for age (continuous) and calendar time

†Adjusted for age (continuous), calendar time, years of education (≤12, 13–15, 16, ≥17), family income (≤$25,000, $25,001–$50,000, $50,001–$100,000, >$100,000), number of persons in the household (1, 2, 3, 4, ≥5), marital status (married, divorced/widowed/separated, single), number of cigarettes smoked per day (nonsmoker, <15, 15–24, ≥25), number of drinks per day (<1, 1–6, 7–13, ≥14), vigorous exercise (hours/week) (0, <1, 1–2.9, 3–4.9, 5–6.9, ≥7), walk for exercise (hours/week) (0, <1, 1–2.9, 3–4.9, 5–6.9, ≥7), energy intake (kcal/day) (quintiles), and percentage of calories from fat (quintiles)

Table 3

Incident Obesity by Neighborhood SES Among Women with BMI<25 at Baseline, BWHS 1995–2005

			IRR (95% CI)	
Neighborhood SES	**Obesity Cases**	**Person-years**	**Model 1***	**Model 2†**
Quintile 1 (lowest)	319	15,506	1.55 (1.30, 1.83)	1.32 (1.10–1.59)
Quintile 2	308	15,676	1.48 (1.24, 1.76)	1.35 (1.13–1.61)
Quintile 3	298	16,332	1.32 (1.11, 1.57)	1.25 (1.04–1.49)
Quintile 4	296	17,352	1.22 (1.03, 1.45)	1.19 (1.00–1.42)
Quintile 5 (highest)	223	16,875	1.0	1.0
			$P_{trend}<0.001$	$P_{trend}=0.001$

BMI, body mass index; BWHS, Black Women's Health Study; CI, confidence interval; IRR, incidence rate ratio; SES, socioeconomic status

*Adjusted for age (continuous) and calendar time

†Adjusted for age (continuous), calendar time, years of education (≥12, 13–15, 16, ≥17), family income (≤$25,000, $25,001–$50,000, $50,001–$100,000, >$100,000), number of persons in the household (1, 2, 3, 4, ≥5), marital status (married, divorced/widowed/separated, single), number of cigarettes smoked per day (nonsmoker, <15, 15–24, ≥25), number of drinks per day (<1, 1–6, 7–13, ≥14), vigorous exercise (hours/week) (0, <1, 1–2.9, 3–4.9, 5–6.9, ≥7), walk for exercise (hours/week) (0, <1, 1–2.9, 3–4.9, 5–6.9, ≥7), energy intake (kcal/day) (quintiles), and percentage of calories from fat (quintiles)

Table 4

Mean 10 Year Weight Gain (kgs) and Incident Obesity* by Quintile of Neighborhood SES Within Strata of Education, BWHS 1995–2005

Neighborhood SES	Mean weight change (kg)(95% CI)*	IRR (95% CI)*†
	≤12 years of education	
Quintile 1 (lowest)	5.48 (5.03,5.94)	1.06 (0.56,2.01)
Quintile 2	5.58 (5.01,6.15)	1.27 (0.66,2.44)
Quintile 3	5.63 (5.00,6.27)	0.74 (0.36,1.50)
Quintile 4	5.68 (5.03,6.33)	0.81 (0.38,1.70)
Quintile 5 (highest)	5.55 (4.73,6.37)	1.0
	P_{trend}=0.70	P_{trend}=0.26
	13–15 years of education	
Quintile 1 (lowest)	7.48 (7.08,7.89)	1.23 (0.91,1.66)
Quintile 2	7.43 (7.03,7.83)	1.24 (0.91,1.68)
Quintile 3	7.23 (6.85,7.61)	1.15 (0.84,1.56)
Quintile 4	7.31 (6.91,7.71)	1.01 (0.73,1.39)
Quintile 5 (highest)	7.02 (6.59,7.45)	1.0
	P_{trend}=0.14	P_{trend}=0.06
	≥16 years of education	
Quintile 1 (lowest)	6.89 (6.43,7.35)	1.38 (1.07,1.79)
Quintile 2	6.95 (6.57,7.33)	1.25 (0.98,1.59)
Quintile 3	6.81 (6.50,7.13)	1.29 (1.03,1.62)
Quintile 4	6.55 (6.28,6.85)	1.32 (1.07,1.64)
Quintile 5 (highest)	6.09 (5.84,6.34)	1.0
	P_{trend}=<0.001	P_{trend}=0.03

BWHS, Black Women's Health Study; CI, confidence interval; IRR, incidence rate ratio; SES, socioeconomic status

*Adjusted for age (continuous), calendar time, family income (≤$25,000, $25,001–$50,000, $50,001–$100,000, >$100,000), number of persons in the household (1, 2, 3, 4, ≥5), marital status (married, divorced/widowed/separated, single), number of cigarettes smoked per day (nonsmoker, <15, 15–24, ≥25), number of drinks per day (<1, 1–6, 7–13, ≥14), vigorous exercise (hours/week) (0, <1, 1–2.9, 3–4.9, 5–6.9, ≥7), walk for exercise (hours/week) (0, <1, 1–2.9, 3–4.9, 5–6.9, ≥7), energy intake (kcal/day) (quintiles), and percentage of calories from fat (quintiles)

†Among women with BMI<25 at baseline