American Journal of Epidemiology

Vol. 171, No. 5
DOI: 10.1093/aje/kwp443
Advance Access publication:
February 4, 2010

Original Contribution

Socioeconomic Status and Incidence of Type 2 Diabetes: Results From the Black Women's Health Study

Supriya Krishnan, Yvette C. Cozier*, Lynn Rosenberg, and Julie R. Palmer

* Correspondence to Dr. Yvette C. Cozier, Slone Epidemiology Center at Boston University, 1010 Commonwealth Avenue, 4th Floor, Boston, MA 02215 (e-mail: yvettec@bu.edu).

Initially submitted October 9, 2009; accepted for publication December 8, 2009.

The authors examined the relation between individual and neighborhood socioeconomic status (SES) and type 2 diabetes incidence among African-American women in the prospective Black Women's Health Study. Participants have completed mailed biennial follow-up questionnaires since 1995. US Census block group characteristics were used to measure neighborhood SES. Incidence rate ratios were estimated in clustered survival regression models. During 12 years of follow-up of 46,382 participants aged 30–69 years, 3,833 new cases of type 2 diabetes occurred. In models that included both individual and neighborhood SES factors, incidence rate ratios were 1.28 (95% confidence interval: 1.15, 1.43) for ≤12 years of education relative to ≥17 years, 1.57 (95% confidence interval: 1.30, 1.90) for household income <\$15,000 relative to >\$100,000, and 1.65 (95% confidence interval: 1.46, 1.85) for lowest quintile of neighborhood SES relative to highest. The associations were attenuated after adjustment for body mass index, suggesting it is the key intermediate factor in the pathway between SES and diabetes. The association of neighborhood SES with diabetes incidence was present even among women who were more educated and had a higher family income. Efforts to reduce the alarming rate of diabetes in African-American women must focus on both individual lifestyle changes and structural changes in disadvantaged neighborhoods.

African Americans; diabetes mellitus, type 2; residence characteristics; social class; women

Abbreviations: BMI, body mass index; SES, socioeconomic status.

Recent studies have indicated that the socioeconomic characteristics of a neighborhood can affect health status independent of the socioeconomic status (SES) of an individual (1, 2). Neighborhood environment can influence diet and physical activity through the availability of grocery stores, recreational facilities, and educational resources, and through the social environment of the neighborhood (3–6). In addition, neighborhoods vary with regard to sources of chronic stress (noise, violence, and poverty) (7, 8).

Type 2 diabetes is estimated to affect 20.6 million people in the United States (9). The burden of disease is particularly large among African-American women, for whom the prevalence is almost twice that for non-Hispanic whites (9, 10). Individual SES factors (higher education and income) have been inversely associated with diabetes in both African-American and white women (11–15). However, only 3 studies are known to have examined the possible effects of neighborhood environment (2, 16, 17). Adverse housing conditions were positively associated with an increased risk of diabetes in a small prospective analysis of urban middle-aged African Americans living in St. Louis, Missouri (2). In a cross-sectional analysis of black adults and white adults in the Coronary Artery Risk Development in Young Adults study, neighborhood deprivation was associated with the insulin resistance syndrome (16). In a follow-up study of black, white, and Hispanic adults in the Multi-Ethnic Study of Atherosclerosis, better neighborhood resources for physical activity and healthy foods were associated with a lower incidence of type 2 diabetes (17).

The current analysis extends the research by prospectively examining the relation between neighborhood SES and incidence of type 2 diabetes in a large, geographically diverse cohort of African-American women. It also identifies intermediate factors that could account for a relation between SES and diabetes incidence.

MATERIALS AND METHODS

Study population

The Black Women's Health Study is an ongoing, prospective, follow-up study of African-American women in the United States. The cohort was established in 1995 when women aged 21–69 years were enrolled through questionnaires mailed to subscribers of *Essence* magazine, members of several professional organizations, and friends and relatives of early respondents. The approximately 59,000 women whose addresses were judged to be valid a year after entry constitute the cohort that has been followed by using biennial postal questionnaires. Eighty percent of the women in the baseline cohort have been followed through 2007.

For the present analyses, we excluded women if they already had diabetes (n = 2,965), gestational diabetes (n = 633), or cancer or cardiovascular disease (n = 1,942) at baseline; were pregnant at baseline (n = 958); had missing data on weight, height, or census block group (n = 5,165) at baseline; or had not reached age 30 years by the end of follow-up (n = 983).

Case definition

The baseline questionnaire asked about a history of diabetes, and each follow-up questionnaire asked about a new diagnosis of diabetes. We assessed the accuracy of self-reported diabetes among a sample of 227 women whose physicians provided data from their medical records. The diagnosis of type 2 diabetes was confirmed for 218 (96%) of the women. Of the remaining 9, 3 did not have diabetes, 2 had type 1 diabetes, 2 had gestational diabetes, 1 had steroid-induced diabetes, and 1 was classified as having metabolic syndrome.

Exposure measurement

Black Women's Health Study participants were linked to year 2000 US Census block groups based on the addresses reported on each questionnaire from 1995 to 2005. Census block groups are subdivisions of US Census tracts containing an average of 1,500 people (18) and have been used as proxies for neighborhoods in other studies (1, 16, 19). Geocoding at the census block group level was performed by a commercial firm, Mapping Analytics (Rochester, New York), which has previously been shown to geocode accurately (20).

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 (21, 22). The 6 variables were median household income; median housing value; percentage of households receiving interest, dividend, or net rental income; percentage of adults aged 25 years or older who have completed college; percentage of employed persons aged 16 years or older who are in occupations classified as managerial, executive, or professional specialty; and percentage of families with children that are not headed by a single female. Regression coefficients from the factor analysis were used to weight the variables for a combined neighborhood score (22). The score was divided into quintiles, with the lowest quintile representing lowest neighborhood SES and the highest quintile representing highest neighborhood SES. Individual SES was characterized by years of education and by annual family income. Educational status was ascertained at baseline and again in 2003; family income and number of people supported by that income were ascertained in 2003.

Assessment of covariates

Self-reported information on weight, height, family history of diabetes, marital status, vigorous physical activity, smoking status, alcohol intake, and menopausal female hormone use was obtained at baseline in 1995. Daily energy intake was estimated from a food frequency questionnaire (23, 24) included in the baseline questionnaire, using National Cancer Institute DIETSYS software (25). Data on weight, vigorous physical activity, smoking status, alcohol intake, and female hormone use were updated on biennial follow-up questionnaires. With regard to physical activity, the women were asked how many hours per week in the past year they spent in vigorous activity such as running, swimming, basketball, and aerobics. In a validation study within the Black Women's Health Study, questionnaire reports of vigorous activity were significantly associated with physical activity as measured by actigraphs and physical activity diaries, and technician-measured weight and height were highly correlated with self-reported measures (26). Body mass index (BMI) was calculated as weight in kilograms divided by squared height in meters.

Analysis

Person-years were calculated from baseline to year of diagnosis of type 2 diabetes, loss to follow-up, death, or end of follow-up (March 2007), whichever occurred first. Time-varying covariates were reassigned every 2 years by using the Anderson-Gill data structure (27). This data structure creates a new record for every follow-up cycle at which the participant is at risk, and it assigns covariate values reported for that specific questionnaire cycle. Thus, quintile of neighborhood SES was updated every 2 years, so that if a woman moved and her new residence was in a block classified in a different quintile than her previous address, her neighborhood SES value would change for the new period of risk.

Clustered survival regression models in SAS (version 8.02 software (*SAS/STAT User's Manual*; SAS Institute, Inc., Cary, North Carolina)) (PROC GENMOD) were used to estimate incidence rate ratios and 95% confidence intervals for the associations of the individual and neighborhood SES variables with diabetes. These methods specify a piecewise exponential survival distribution, approximate the proportional hazards regression models, and account for correlation among those living in the same block group using generalized estimating equations (28).

Incidence rate ratios were calculated for increasing levels of neighborhood score, years of education, and family

Table 1. Baseline Individual Characteristics Across Quintiles of Neighborhood SES Score in the Black Women's Health Study ($N = 46{,}382$), United States, 1995

	Quintile 1: Lowest SES	Quintile 2	Quintile 3	Quintile 4	Quintile 5: Highest SES
Age, years (mean (SD))	38.6 (10.6)	38.6 (10.4)	38.4 (10.3)	38.3 (10.1)	39.4 (10.3)
BMI, kg/m^2 (mean (SD))	29.0 (7.1)	28.2 (6.6)	27.6 (6.3)	27.2 (6.1)	26.3 (5.7)
Energy intake, kcal (mean (SD))	1,657 (733)	1,594 (701)	1,561 (687)	1,535 (658)	1,516 (646)
Education ≥16 years, %	28.2	38.8	45.8	53.1	65.4
Household income >$50,000, %[a]	25.2	36.0	44.4	51.1	59.7
Married/living as married, %	31.4	35.2	39.1	44.0	48.1
Family history of diabetes, %	26.9	26.2	26.1	25.4	24.1
≥15 Cigarettes/day, %	13.1	11.8	11.0	11.1	10.9
≥7 Alcoholic beverages/week, %	7.2	6.1	5.6	4.7	5.7
No vigorous activity, %	37.9	34.4	30.3	26.9	24.3
Female hormone use (ever), %	14.9	14.7	14.8	14.9	16.1

Abbreviations: BMI, body mass index; SD, standard deviation; SES, socioeconomic status.
[a] Income data were obtained in 2003.

income relative to the lowest level of each. In an initial model, we included terms for age (years), questionnaire cycle, years of education (≤12, 13–15, 16, ≥17), family income (<$15,000, $15,001–$25,000, $25,001–$35,000, $35,001–$50,000, $50,001–$100,000, >$100,000), number of individuals in the household (1, 2, 3, 4, ≥5), and marital status (single, married, divorced/separated/widowed). In a second model, we added terms for family history of diabetes (yes, no), cigarettes smoked per day (none, <15, 15–24, ≥25), alcoholic drinks per week (none, 1–6, 7–13, ≥14), daily energy intake (kcal, quintiles), hours per week of vigorous activity (none, <1, 1–2, 3–4, 5–6, ≥7), and menopausal female hormone therapy (ever/never). In a third model, we added a term for BMI (continuous).

Tests for linear trend across categories of SES variables were carried out by including an ordinal term for increasing levels of exposure. Subgroup analyses were performed within categories of BMI, education, and income. Tests for interaction were performed by using a likelihood ratio test to compare models with and without interaction terms.

RESULTS

Included in the present analysis were 46,382 women distributed across 23,329 block groups. Table 1 displays the baseline characteristics of the Black Women's Health Study population by quintile of neighborhood score. Compared with women in higher quintiles, women in the lowest quintile of neighborhood score had a higher mean BMI and energy intake; were more likely to smoke cigarettes, drink alcohol, and have a family history of diabetes; and were less educated, were less physically active, and had a lower income.

From 1995 to 2007, 3,833 cases of incident diabetes occurred during 425,768 person-years of follow-up. As shown in Table 2, each of the SES variables was inversely associated with incidence of diabetes. In a model that included terms for age, time period, and SES factors (model 1), the incidence rate ratios were 1.28 (95% confidence interval: 1.15, 1.43) for ≤12 years of education relative to ≥17, 1.57 (95% confidence interval: 1.30, 1.90) for lowest family income relative to highest, and 1.65 (95% confidence interval: 1.46, 1.85) for lowest neighborhood SES quintile relative to highest. The estimates were somewhat reduced by control for behavioral risk factors such as smoking, physical activity, and energy intake (model 2). Adding a term for BMI (model 3) reduced the incidence rate ratios markedly, to 1.20 for education, 1.20 for income, and 1.26 for neighborhood SES. The analysis of neighborhood SES in relation to type 2 diabetes was repeated among women who had stayed in the same quintile of neighborhood SES through 2007, about 53% of the study sample. A similar association was observed as in the overall data (data not shown).

We repeated the neighborhood SES analyses separately within strata of BMI, individual educational level, and individual income level (Table 3). Diabetes incidence was elevated for those in the lowest SES neighborhood in each stratum of BMI, but there was a statistically significant trend among only those women with a BMI ≥30 kg/m^2. Neighborhood SES was associated with diabetes incidence among only women who had more than 12 years of education. With regard to family income, the association of neighborhood SES with diabetes incidence was observed among women in the highest income category only, >$50,000 per year. In tests for interaction, no statistically significant differences were found in the associations across levels of BMI, education, and income.

Finally, we examined separately each of the 6 census factors that contributed to neighborhood SES score. Each factor was associated with diabetes incidence, with median housing value of the neighborhood being the most strongly associated (data not shown).

DISCUSSION

The present study suggests that both individual and neighborhood SES play a role in the development of diabetes in black women. Lower individual levels of education and income and lower levels of neighborhood SES were independently associated with an increased risk of type 2

Table 2. Socioeconomic Factors in Relation to Incidence of Type 2 Diabetes in the Black Women's Health Study, United States, 1995–2007

	No. of Cases	No. of Person-Years	IRR	95% CI[a]	IRR	95% CI[b]	IRR	95% CI[c]
Participant's education, years								
≤12	937	74,778	1.28	1.15, 1.43	1.24	1.11, 1.39	1.20	1.08, 1.35
13–15	1,393	146,588	1.21	1.09, 1.33	1.19	1.08, 1.32	1.14	1.04, 1.27
16	747	104,075	1.05	0.95, 1.17	1.06	0.95, 1.18	1.07	0.96, 1.19
≥17	750	99,816	1.0		1.0		1.0	
P_{trend}			<0.0001		<0.0001		0.0002	
Participant's household income, $								
<15,000	231	16,038	1.57	1.30, 1.90	1.43	1.18, 1.73	1.20	0.99, 1.47
15,001–25,000	301	25,474	1.27	1.07, 1.52	1.16	0.98, 1.39	1.06	0.89, 1.27
25,001–35,000	447	38,360	1.42	1.21, 1.67	1.34	1.14, 1.57	1.24	1.05, 1.45
35,001–50,000	673	70,686	1.31	1.14, 1.51	1.23	1.07, 1.42	1.16	1.00, 1.34
50,001–100,000	1,151	142,632	1.24	1.10, 1.41	1.20	1.06, 1.35	1.14	1.01, 1.29
>100,000	352	65,049	1.0		1.0		1.0	
P_{trend}			<0.0001		0.0008		0.09	
Neighborhood SES score								
Quintile 1 (lowest SES)	1,015	82,362	1.65	1.46, 1.85	1.48	1.32, 1.67	1.26	1.12, 1.42
Quintile 2	796	80,876	1.40	1.25, 1.58	1.29	1.15, 1.45	1.18	1.05, 1.33
Quintile 3	766	83,226	1.38	1.23, 1.55	1.29	1.15, 1.45	1.21	1.08, 1.36
Quintile 4	704	89,525	1.22	1.08, 1.36	1.18	1.05, 1.32	1.12	1.00, 1.26
Quintile 5 (highest SES)	552	89,776	1.0		1.0		1.0	
P_{trend}			<0.0001		<0.0001		<0.0001	

Abbreviations: CI, confidence interval; IRR, incidence rate ratio; SES, socioeconomic status.
[a] Model 1: adjusted for age, time period, individual SES variables (education, household income, household size, and marital status), and neighborhood SES.
[b] Model 2: adjusted for all variables in model 1 plus family history of diabetes, smoking, alcohol intake, energy intake, vigorous activity, and female hormone use.
[c] Model 3: adjusted for all variables in model 2 plus body mass index.

diabetes. These associations appeared to be primarily mediated by BMI. The association of neighborhood SES with diabetes risk was most evident among women with the most education and the highest income.

Robbins et al. (11) found that lower individual levels of income, education, and occupation were positively associated with prevalence of diabetes in white women but that income was the only SES factor significantly associated with diabetes in black women; the findings for black women were based on 193 cases of diabetes. Other studies of predominantly white populations also found an inverse association of individual SES with diabetes risk (12–15). The present results, based on 3,833 incident cases from a prospective cohort of 46,382 African-American women, strengthen the evidence for an association of individual SES with diabetes risk and extend the research by showing that the association was primarily mediated by BMI.

In cross-sectional data from the Coronary Artery Risk Development in Young Adults study, living in a disadvantaged neighborhood was associated with a higher prevalence of insulin resistance syndrome, even after accounting for individual factors such as income and education (16). A small, prospective study of African Americans, 65 of whom developed diabetes over a 3-year period, indicated that adverse housing conditions, classified on the basis of interviewer observations, were associated with the development of diabetes (2). The present study of African-American women found a similar independent association between living in a disadvantaged neighborhood and incidence of diabetes. Of interest, the association of neighborhood SES with type 2 diabetes incidence was statistically significant among college-educated women and women with a family income of >$50,000 per year. These results suggest that even women with higher personal levels of SES are

Table 3. Neighborhood Socioeconomic Status in Relation to Incidence of Type 2 Diabetes, Stratified by BMI, Education, and Income, in the Black Women's Health Study, United States, 1995–2007[a]

Neighborhood SES	No. of Cases	IRR	95% CI	No. of Cases	IRR	95% CI	No. of Cases	IRR	95% CI
	BMI <25 kg/m²			*BMI 25–29 kg/m²*			*BMI ≥30 kg/m²*		
Quintile 1	52	1.42	0.91, 2.21	247	1.24	1.00, 1.54	716	1.24	1.07, 1.44
Quintile 2	54	1.36	0.88, 2.09	165	0.87	0.69, 1.09	577	1.25	1.08, 1.45
Quintile 3	49	1.34	0.87, 2.07	226	1.20	0.98, 1.47	471	1.18	1.01, 1.36
Quintile 4	50	1.20	0.79, 1.83	201	1.05	0.85, 1.29	453	1.13	0.97, 1.31
Quintile 5	46	1.0		183	1.0		323	1.0	
P_{trend}		0.08			0.26			0.003	
	Education ≤12 years			*Education 13–15 years*			*Education ≥16 years*		
Quintile 1	364	1.06	0.81, 1.40	388	1.30	1.07, 1.60	263	1.38	1.15, 1.65
Quintile 2	217	1.05	0.80, 1.40	314	1.23	1.01, 1.51	261	1.17	0.98, 1.39
Quintile 3	158	0.98	0.73, 1.31	283	1.22	1.00, 1.50	325	1.34	1.13, 1.57
Quintile 4	125	0.97	0.71, 1.32	248	1.13	0.92, 1.30	331	1.18	1.00, 1.38
Quintile 5	73	1.0		160	1.0		317	1.0	
P_{trend}		0.38			0.008			0.001	
	Income <$25,000			*Income $25,001–$50,000*			*Income >$50,000*		
Quintile 1	247	1.11	0.76, 1.62	342	1.15	0.92, 1.45	238	1.56	1.29, 1.85
Quintile 2	124	1.12	0.76, 1.65	257	1.08	0.86, 1.37	253	1.18	0.99, 1.41
Quintile 3	72	0.93	0.61, 1.42	255	1.11	0.87, 1.41	347	1.43	1.22, 1.68
Quintile 4	54	1.07	0.69, 1.66	189	1.07	0.84, 1.37	358	1.23	1.06, 1.44
Quintile 5	35	1.0		107	1.0		307	1.0	
P_{trend}		0.42			0.23			<0.0001	

Abbreviations: BMI, body mass index; CI, confidence interval; IRR, incidence rate ratio; SES, socioeconomic status.

[a] Models include terms for age, time period, education, household income, household size, marital status, BMI, family history of diabetes, smoking, alcohol intake, energy intake, vigorous activity, and female hormone use.

susceptible to the negative influences of living in disadvantaged neighborhoods.

Neighborhood SES may affect the risk of diabetes through mechanisms such as availability of healthy foods or recreational facilities, as indicated in the recent study of neighborhood resources for healthy foods and physical activity in relation to type 2 diabetes in the Multi-Ethnic Study of Atherosclerosis (17). African Americans living in higher income neighborhoods have been shown to have healthier diets than African Americans living in lower income neighborhoods (3, 6). Evidence also suggests that location of food stores and supermarkets is associated with the wealth and racial makeup of the neighborhood, such that lower income neighborhoods and minority neighborhoods have fewer supermarkets than white neighborhoods do (6). Furthermore, these neighborhoods have a greater proportion of households without access to private transportation, leaving residents to rely on their immediate neighborhoods for access to food. Poor and minority neighborhoods are less likely to have adequate recreational facilities such as gyms, tennis courts, and parks (4). Concerns about safety may also influence individual participation in outdoor physical activity (5).

The association of neighborhood SES with diabetes incidence in our study appeared to be present at all levels of BMI. This finding suggests that BMI is not the only intermediate in the pathway between the neighborhood environment and diabetes risk. It is possible that the effects of neighborhood on diabetes risk are also mediated by the chronic stress brought on by adverse neighborhood characteristics such as noise, violence, and poverty (7, 8). Chronic stress may lead to insulin resistance through endocrine pathways involving the hypothalamic-pituitary-adrenal axis or activation of the sympathetic nervous system (29, 30). In a study of Swedish women, moderate psychological distress, measured as insomnia, apathy, anxiety, depression, and fatigue, had a significant association with increased prediabetes (31).

An important strength of our study is the prospective design, which obviates recall bias. The follow-up rates were high, reducing the likelihood of differential loss related to both exposure and outcome. Important confounding factors were taken into account in the analysis. The use of 6 census measures to create a neighborhood SES score likely captured SES better than use of a single factor. A similar approach was used by Diez Roux et al. (16) in their study of neighborhood characteristics and components of the insulin resistance syndrome.

A limitation of our study is that family income data were collected only once, and in 2003 rather than at baseline in 1995. Therefore, we cannot be certain about the directionality of any associations between income and diabetes incidence; it is possible that living with type 2 diabetes may have led to a reduction in income level for some women.

Identification of diabetes cases was based on self-report. A validation study indicated that type 2 diabetes was reported with a high degree of accuracy. Some women with undiagnosed diabetes were undoubtedly misclassified as noncases, but the prevalence of undiagnosed disease was likely to be low. In the Third National Health and Nutrition Examination Survey (1999–2002), the prevalence of undiagnosed diabetes in black women was 4.1% (32). Undiagnosed diabetes among noncases in our study would have had a negligible effect on the risk estimates.

Black Women's Health Study participants are from across the United States, with approximately equal numbers from the Northeast, South, West, and Midwest. Ninety-seven percent of the participants have completed high school or a higher level of education. Among the US black female population of the same ages, 83% have at least a high school education (33). Our results should therefore be applicable to most US black women. The sizable number of well-educated participants is a strength of the study because it permitted disentanglement of individual and neighborhood factors.

The present findings indicate that the risk of type 2 diabetes for African-American women is influenced not only by their individual characteristics but also by the characteristics of the neighborhoods in which they live. Even women with the highest levels of education appeared to be affected by their neighborhood environment. These findings are of particular relevance because many African Americans continue to live in disadvantaged neighborhoods even while they work in professional jobs and earn adequate incomes (34). Efforts to reduce the alarming rate of diabetes in African-American women need to focus not only on individual lifestyle changes but also on improving conditions in disadvantaged neighborhoods.

ACKNOWLEDGMENTS

Author affiliations: Slone Epidemiology Center at Boston University, Boston, Massachusetts (Supriya Krishnan, Yvette C. Cozier, Lynn Rosenberg, Julie R. Palmer); and Center for Biostatistics in AIDS Research, Harvard University, Boston, Massachusetts (Supriya Krishnan).

This work was supported by National Cancer Institute grant CA58420 and National Institute of Diabetes and Digestive and Kidney Diseases grant DK068738.

The authors acknowledge the dedication of the Black Women's Health Study staff.

Conflict of interest: none declared.

REFERENCES

1. Diez-Roux AV, Nieto FJ, Muntaner C, et al. Neighborhood environments and coronary heart disease: a multilevel analysis. *Am J Epidemiol*. 1997;146(1):48–63.
2. Schootman M, Andresen EM, Wolinsky FD, et al. The effect of adverse housing and neighborhood conditions on the development of diabetes mellitus among middle-aged African Americans. *Am J Epidemiol*. 2007;166(4):379–387.
3. Diez-Roux AV, Nieto FJ, Caulfield L, et al. Neighbourhood differences in diet: the Atherosclerosis Risk in Communities (ARIC) Study. *J Epidemiol Community Health*. 1999;53(1): 55–63.
4. Moore LV, Diez Roux AV, Evenson KR, et al. Availability of recreational resources in minority and low socioeconomic status areas. *Am J Prev Med*. 2008;34(1):16–22.
5. Yen IH, Kaplan GA. Poverty area residence and changes in physical activity level: evidence from the Alameda County Study. *Am J Public Health*. 1998;88(11):1709–1712.
6. Morland K, Wing S, Diez Roux A. The contextual effect of the local food environment on residents' diets: the Atherosclerosis Risk in Communities Study. *Am J Public Health*. 2002;92(11): 1761–1767.
7. Anderson RT, Sorlie P, Backlund E. Mortality effects of community socioeconomic status. *Epidemiology*. 1997;8(1): 42–47.
8. Sundquist K, Theobald H, Yang M, et al. Neighborhood violent crime and unemployment increase the risk of coronary heart disease: a multilevel study in an urban setting. *Soc Sci Med*. 2006;62(8):2061–2071.
9. National Institute of Diabetes and Digestive and Kidney Diseases. *National Diabetes Statistics Fact Sheet*. Bethesda, MD: US Department of Health and Human Services, National Institutes of Health; 2008. (NIH publication 08-3892).
10. Mokdad AH, Ford ES, Bowman BA, et al. Diabetes trends in the U.S.: 1990–1998. *Diabetes Care*. 2000;23(9):1278–1283.
11. Robbins JM, Vaccarino V, Zhang H, et al. Socioeconomic status and type 2 diabetes in African American and non-Hispanic white women and men: evidence from the Third National Health and Nutrition Examination Survey. *Am J Public Health*. 2001;91(1):76–83.
12. Lidfeldt J, Li TY, Hu FB, et al. A prospective study of childhood and adult socioeconomic status and incidence of type 2 diabetes in women. *Am J Epidemiol*. 2007;165(8):882–889.
13. Agardh EE, Ahlbom A, Andersson T, et al. Socio-economic position at three points in life in association with type 2 diabetes and impaired glucose tolerance in middle-aged Swedish men and women. *Int J Epidemiol*. 2007;36(1):84–92.
14. Rathmann W, Haastert B, Icks A, et al. Sex differences in the associations of socioeconomic status with undiagnosed diabetes mellitus and impaired glucose tolerance in the elderly population: the KORA Survey 2000. *Eur J Public Health*. 2005;15(6):627–633.
15. Robbins JM, Vaccarino V, Zhang H, et al. Socioeconomic status and diagnosed diabetes incidence. *Diabetes Res Clin Pract*. 2005;68(3):230–236.
16. Diez Roux AV, Jacobs DR, Kiefe CI. Neighborhood characteristics and components of the insulin resistance syndrome in young adults: the Coronary Artery Risk Development in Young Adults (CARDIA) study. *Diabetes Care*. 2002;25(11): 1976–1982.
17. Auchincloss AH, Diez Roux AV, Mujahid MS, et al. Neighborhood resources for physical activity and healthy foods and incidence of type 2 diabetes mellitus: the Multi-Ethnic Study of Atherosclerosis. *Arch Intern Med*. 2009;169(18): 1698–1704.
18. US Census Bureau. *Census 2000 Basics*. Washington, DC: US Government Printing Office; 2002. (http://www.census.gov/geo/www/tiger/glossry2.pdf). (Accessed January 22, 2010).

19. Cozier YC, Palmer JR, Horton NJ, et al. Relation between neighborhood median housing value and hypertension risk among black women in the United States. *Am J Public Health*. 2007;97(4):718–724.
20. Krieger N, Waterman P, Lemieux K, et al. On the wrong side of the tracts? Evaluating the accuracy of geocoding in public health research. *Am J Public Health*. 2001;91(7):1114–1116.
21. Kim J, Mueller CW. *Introduction to Factor Analysis: What It Is and How To Do It*. Beverly Hills, CA: Sage Publications; 1978.
22. Kleinbaum DL, Kupper LL, Muller KE. *Applied Regression Analysis and Other Multivariable Methods*. 2nd ed. Boston, MA: PWS-Kent Publishing Co; 1998.
23. Block G, Hartman AM, Naughton D. A reduced dietary questionnaire: development and validation. *Epidemiology.* 1990;1(1):58–64.
24. Kumanyika SK, Mauger D, Mitchell DC, et al. Relative validity of food frequency questionnaire nutrient estimates in the Black Women's Health Study. *Ann Epidemiol*. 2003;13(2): 111–118.
25. Block G, Coyle LM, Hartman AM, et al. Revision of dietary analysis software for the Health Habits and History Questionnaire. *Am J Epidemiol*. 1994;139(12):1190–1196.
26. Carter-Nolan PL, Adams-Campbell LL, Makambi K, et al. Validation of physical activity instruments: Black Women's Health Study. *Ethn Dis*. 2006;16(4):943–947.
27. Laird N, Olivier D. Covariance analysis of censored survival data using log-linear analysis techniques. *J Am Stat Assoc.* 1981;76:231–240.
28. Horton NJ, Lipsitz SR. Review of software to fit generalized estimating equation (GEE) regression models. *Am Stat*. 1999; 53:160–169.
29. Brunner E. Stress and the biology of inequality. *BMJ*. 1997; 314(7092):1472–1476.
30. Björntorp P, Rosmond R. Hypothalamic origin of the metabolic syndrome X. *Ann N Y Acad Sci.* 1999;892:297–307.
31. Eriksson AK, Ekbom A, Granath F, et al. Psychological distress and risk of pre-diabetes and type 2 diabetes in a prospective study of Swedish middle-aged men and women. *Diabet Med*. 2008;25(7):834–842.
32. Harris MI, Flegal KM, Cowie CC, et al. Prevalence of diabetes, impaired fasting glucose, and impaired glucose tolerance in U.S. adults. The Third National Health and Nutrition Examination Survey, 1988–1994. *Diabetes Care*. 1998;21(4):518–524.
33. US Census Bureau: *Educational Attainment in the US, March 1999*. Washington, DC: US Department of Commerce; 2000. (http://www.census.gov/population/socdemo/education/p20-528/tab01a.pdf). (Accessed January 22, 2010).
34. Massey DS, Denton NA. The continuing causes of segregation. In: Massey DS, Denton NA, eds. *American Apartheid: Segregation and the Making of the Underclass*. Cambridge, MA: Harvard University Press; 1993:83–114.