ORIGINAL RESEARCH

Cardiovascular Disease Burden and Socioeconomic Correlates: Findings From the Jackson Heart Study

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Background—Black persons have an excess burden of cardiovascular disease (CVD) compared with white persons. This burden persists after adjustment for socioeconomic status and other known CVD risk factors. This study evaluated the CVD burden and the socioeconomic gradient of CVD among black participants in the JHS (Jackson Heart Study).

Methods and Results—CVD burden was evaluated by comparing the observed prevalence of myocardial infarction, stroke, and hypertension in the JHS at baseline (2000–2004) with the expected prevalence according to US national surveys during a similar time period. The socioeconomic gradient of CVD was evaluated using logistic regression models. Compared with the national data, the JHS age- and sex-standardized prevalence ratios for myocardial infarction, stroke, and hypertension were 1.07 (95% CI, 0.90–1.27), 1.46 (95% CI, 1.18–1.78), and 1.51 (95% CI, 1.42–1.60), respectively, in men and 1.50 (95% CI, 1.27–1.76), 1.33 (95% CI, 1.12–1.57), and 1.43 (95% CI, 1.37–1.50), respectively, in women. A significant and inverse relationship was observed between socioeconomic status and CVD within the JHS cohort. The strongest and most consistent socioeconomic correlate after adjusting for age and sex was income for myocardial infarction (odds ratio: 3.53; 95% CI, 2.31–5.40) and stroke (odds ratio: 3.73; 95% CI, 2.32–5.97), comparing the poor and affluent income categories.

Conclusions—Except for myocardial infarction in men, CVD burden in the JHS cohort was higher than expected. A strong inverse socioeconomic gradient of CVD was also observed within the JHS cohort. **(*J Am Heart Assoc.* 2017;6:e004416. DOI: 10.1161/JAHA.116.004416.)**

Key Words: cardiovascular disease • health disparities • socioeconomic position

Despite declines in mortality from cardiovascular disease (CVD), CVD remains the leading cause of death in the United States, and racial and ethnic disparities in CVD persist. In 2010, rates of CVD mortality per 100 000 were 192.2 for white women, 260.5 for black women, 278.4 for white men, and 369.2 for black men.[1] In 2012, although the age-adjusted prevalence of coronary heart disease was similar for adult black and white populations, the prevalence estimates for hypertension and stroke were higher for black than for white persons.[2] A number of known risk factors, such as blood pressure, body mass index, and socioeconomic status (SES), can be postulated to explain the observed racial/ethnic disparities in CVD. However, disparities in CVD persist between black and white persons even when these known risk factors are taken into account.[3] Some questions remain regarding the extent to which unexplained white–black variation in health outcomes is real or due to residual confounding by SES disparities between white and black persons, either because of inadequate SES measurements or failure to include similar representation of all SES strata from the 2 groups under comparison.[4,5] Furthermore, the fact that low SES is more common among black populations also may have limited evaluations of possible socioeconomic gradients of CVD among black populations. Consequently, whether black populations with a wider representation of SES are likely to exhibit an excess burden of CVD compared with the

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Clinical Perspective

What Is New?

- There is an excess burden of cardiovascular disease among black persons compared with the US general population by similar socioeconomic status.
- An inverse association was shown between socioeconomic status and burden of cardiovascular disease in black persons, similar to that observed in the general population.

What Are the Clinical Implications?

- The excess burden of cardiovascular disease in black persons may be greatly reduced by improved socioeconomic position; however, it may not be completely eliminated without further understanding the role of cultural and psychosocial factors specific to black Americans.

general population and a socioeconomic gradient of CVD burden is unclear. We sought to evaluate these questions in the JHS (Jackson Heart Study).

We performed a cross-sectional analysis using data collected in the JHS at baseline. The purpose of our analysis was 2-fold: to evaluate (1) whether the JHS cohort had a higher burden of CVD compared with the US general population and (2) whether the burden of CVD within the JHS cohort varied by SES. The JHS is a prospective cohort study to investigate risk factors for CVD among black persons residing in the Jackson, Mississippi, metropolitan area. Because the SES of the JHS participants is more similar to the US general population than to the black population in general, we believe the results of the study can provide new insights into the black–white disparity in CVD burden.

Methods

Data Source

The design and data collection of the JHS was described previously.[6,7] Between September 2000 and March 2004, >5000 black Americans aged 20 to 95 years who were living in the Jackson, Mississippi, metropolitan area were enrolled. Three clinical examinations were conducted between 2000 and 2013 (exam 1 [baseline]: 2000–2004; exam 2: 2005–2008; exam 3: 2009–2013). Surveillance of CVD events and deaths is still ongoing. The study was approved by the institutional review boards of the 3 participating universities (University of Mississippi Medical Center, Jackson State University, and Tougaloo College), and participants provided informed consent.

For the purpose of this analysis, only data collected at baseline were used. CVD burden in the JHS was assessed by the prevalence of myocardial infarction (MI), stroke, and hypertension at baseline. The prevalence of MI was calculated based on self-reports of diagnosis of MI by a doctor or health professional or hospitalization for MI (≥1 week). The prevalence of stroke was calculated based on self-reports of diagnosis of stroke by a doctor or health professional. The prevalence of hypertension was calculated based on blood pressure measured at baseline (systolic blood pressure ≥140 mm Hg or diastolic blood pressure of ≥90 mm Hg) or self-reported use of antihypertension medications during the 2-week period before the baseline exam.

SES measures analyzed included educational attainment, income, and occupation. Education was measured as years of schooling completed and included 4 categories: less than high school (<12 years), high school graduate or GED equivalent, some college, and college graduate and above. Participants were assigned to 1 of 4 income categories, according to the US census poverty levels based on household income and family size: poor, representing income less than poverty level; lower-middle, representing income 1 to 1.5 times the poverty level; upper-middle, representing income >1.5 but <3.5 times the poverty level; and affluent, representing income ≥3.5 times the poverty level.[8] Coding of the industry and occupation data was a joint effort between the JHS, the JHS Vanguard Center at the National Institute for Occupational Safety and Health (NIOSH), and the NIOSH Industry and Occupation Coding Team. Occupation was coded based on self-reported job histories (current job, if employed; last job held if unemployed or retired) according to the 2002 US Census occupation codes. For the purpose of this analysis, occupation codes were classified as managerial or professional (0010–3540), service or sales (3600–5930), construction or production (6200–9750), and other.[9] Because the *other* category included various categories with small numbers of participants, this category was included only in the baseline table (ie, Table 1) and was excluded from further analysis.

The burden of CVD risk factors in the JHS cohort was captured by a Life's Simple Seven (LSS) score, indicating the number of American Heart Association cardiovascular health metrics meeting the criteria for ideal health (smoking, body mass index, physical activity, nutrition, total cholesterol, blood pressure, and glucose/hemoglobin A1c levels). The LSS score ranges from 0 to 7. A higher score indicates better cardiovascular health. Note that in the analysis of prevalent hypertension, the LSS score was calculated with only 6 cardiovascular health metrics, removing the metric for blood pressure (LSS score range 0–6). The criteria for ideal health for each of the LSS components are as follows: (1) smoking: never smoked or quit ≥12 months ago; (2) body mass index <25; (3) physical activity per week: ≥150 minutes of moderate physical activity, ≥75 minutes of vigorous physical activity, or ≥150 minutes of combined moderate and vigorous

Table 1. Characteristics of the JHS Participants Versus US Population

Participant Characteristics at Baseline (2000–2004)	JHS (N=5301) n (%)	US 2000 Census,* %
Age, y		
20–44	1256 (23.7)	51.1
45–64	2738 (51.7)	31.1
65–74	999 (18.9)	9.3
75–84	293 (5.5)	6.3
≥85	15 (0.3)	2.2
Sex		
Male	1934 (36.5)	49.1
Female	3367 (63.5)	50.9
Education		
Less than high school	1075 (20.4)	19.6
High school graduate	974 (18.4)	28.6
Some college	1518 (28.7)	27.4
College graduate	1714 (32.5)	24.4
Occupation		
Management/professional	1881 (35.9)	33.6
Service/sales	2206 (42.1)	41.6
Construction/production/other†	1154 (22.0)	24.7
Personal income		
<$35 000	3279 (72.1)	72.5
≥$35 000 to <$50 000	663 (14.6)	11.9
≥$50 000	608 (13.4)	15.5
Household income		
<$35 000	2314 (51.3)	41.9
≥$35 000 to <$50 000	663 (14.7)	15.5
≥$50 000	1532 (34.0)	42.7

The totals for education (n=5281), occupation (n=5241), personal income (n=4550), and household income (n=4509) do not add up to the total number of participants (N=5301) because of missing data. The percentages do not add up to 100% because of rounding. JHS indicates Jackson Heart Study.

*The data presented are for the entire US population and are not restricted to black Americans only to provide context for the comparison of CVD burden in the JHS and the US population as a whole.

†The *other* category includes farming, fishing, and forestry occupations (n=12); homemakers, students, and did not work (n=25); and military (n=11). Given the small number of participants in the other category (n=48), these participants were included in this table but were excluded from further analyses that included occupation as a covariate.

physical activity; (4) nutrition: at least 4 of the following 5 components (based on 2000-kcal diet): fruits and vegetables ≥4.5 cups/day, fish >3.5 oz twice per week, sodium <1500 mg/day, sugary beverages <450 kcal/week, or whole grains ≥3 servings per day; (5) total cholesterol <200 mg/dL (if untreated); (6) blood pressure: systolic <120 mm Hg (if untreated) and diastolic <80 mm Hg (if untreated); (7) glucose/hemoglobin A1c: fasting plasma glucose <100 mg/dL, hemoglobin A1c <5.7%, and no report of taking diabetes mellitus medications.

Statistical Analysis

Excess CVD burden was evaluated by comparing the baseline prevalence of MI, stroke, and hypertension in the JHS with population estimates as reported by US national survey data during periods comparable to the JHS baseline exam (2000–2004). Data from multiple survey years were combined to increase the reliability of the national estimates. Specifically, for the prevalence of MI and stroke, National Health Interview Survey estimates from 4 survey years 2001 to 2004 were used for comparison.[10] For the prevalence of hypertension, National Health and Nutrition Examination Survey estimates from the 2 exam cycles 2001–2002 and 2003–2004 were used for comparison.[11] Age- and sex-standardized prevalence ratios (SPRs) were calculated as the ratio of the observed prevalence in JHS to the expected prevalence according to population estimates. The 95% confidence interval (CI) of SPR was calculated using the method by Ulm,[12] as follows: the lower confidence limit=$[x^2_{\alpha/2,2d}] \times 0.5/e$ and the upper confidence limit=$[x^2_{1-\alpha/2,2(d+1)}] \times 0.5/e$, where, $x^2_{a,v}$ is the $(100\times\alpha)$th χ^2 centile with *v* degrees of freedom, *d* is the number of observed events, and *e* is the number of expected events. An SPR >1 indicates that the observed prevalence in JHS is greater than expected based on population estimates. A statistically significant excess burden is suggested if the lower 95% confidence limit of the SPR is >1.

The socioeconomic gradient of CVD burden was evaluated within the JHS cohort. Logistic regression models were used to adjust for age, sex, and LSS score. Three models (collectively referred to as *model 1*) were fitted separately for each SES variable to obtain their age- and sex-adjusted effect on CVD outcomes. Three models (collectively referred to as *model 2*) were fitted separately for each SES variable to obtain their age-, sex-, and LSS score–adjusted effect on CVD outcomes. Finally, a model (*model 3*) that included age, sex, LSS score, and all 3 SES variables was fitted to obtain the age-, sex-, and LSS score–adjusted effect of each SES variable on CVD outcomes while adjusting for the other 2 SES variables. Both age and LSS score were included in the model as continuous variables. Because the SES variables were expected to be correlated, a backward selection procedure was used to explore the relative importance of SES variables. For this analysis, age, sex, and LSS score were forced into the models.

For the primary analysis, only observed data were used. No imputations were made to account for missing data. About 16.4% of the participants did not have data for 1 of the SES variables, most notably income (15.5% missing income, 0.4%

missing education, and 1.1% missing occupation), and 23% did not have data for the covariate LSS score. Baseline characteristics between participants with and without missing data were compared.

Sensitivity analysis

Sensitivity analyses using multiple imputations for missing data were performed to evaluate the effect of missing data on the robustness of the results. Multiple imputations were implemented using the SAS PROC MI procedure. The Markov chain Monte Carlo method for imputing missing values with an arbitrary missing pattern was used. The variables included in the imputation model were age, sex, LSS score, education, income, and occupation. Twenty imputed data sets were generated for each adjusted analysis. The parameter estimates from each imputed data set were combined using the SAS PROC MIANALYZE procedure.[13] All analyses were conducted using SAS version 9.4 (SAS Institute Inc).

Results

Participant Characteristics

Characteristics of JHS participants are shown in Table 1. Compared with the 2000 US Census population, the JHS cohort was somewhat older and had more women.[14] With respect to SES, the JHS cohort had slightly higher educational attainment compared with the US population. About one third of the JHS participants had a bachelor's degree or higher compared with 24.4% in the US population. The JHS cohort was also comparable to the US population with respect to the type of occupations held, with 35.9% of the participants in management, professional, and related occupations. The distributions of personal income were also similar between the JHS cohort and the US population, with ≈28% reporting a personal income of ≥$35 000.[15] The household income in the JHS cohort appeared lower, with 51.3% of JHS participants reporting a household income of ≤$35 000 compared with 41.8% in the US population.[16] This may, in part, be due to the differential age and sex distributions between the JHS cohort and the US population.

CVD Burden

The age-specific prevalence estimates of MI, stroke, and hypertension in the US and JHS populations by sex are shown in Figures 1 and 2. In general, an increase in the prevalence of MI, stroke, and hypertension with age was observed in both the US and JHS data. The prevalence was higher in the JHS cohort compared with the population estimates, except for MI in men aged ≥65 years and for stroke in both men and women aged ≥75 years. However, the CIs for prevalence in the JHS cohort were wide in the older age groups because of small sample sizes. Of note, the excess burden appeared much earlier in adulthood for hypertension in both men and women in the JHS data compared with the population estimates. The prevalence of hypertension among those aged 20 to 44 years in the JHS was ≈3 times higher compared with the population estimates in men (35% versus 12.5%; Figure 1C) and ≈4 times higher in women (27.2% versus 7.3%; Figure 2C).

The prevalence of MI, stroke, and hypertension in the JHS and the corresponding SPR by sex and the overall SPR are shown in Table 2. The SPR was >1 for all 3 conditions in both men and women, suggesting that the prevalence in the JHS was higher than expected compared with the population estimates (ie, excess burden). Of note, although the prevalence of MI is higher in men than in women, the SPR for MI in

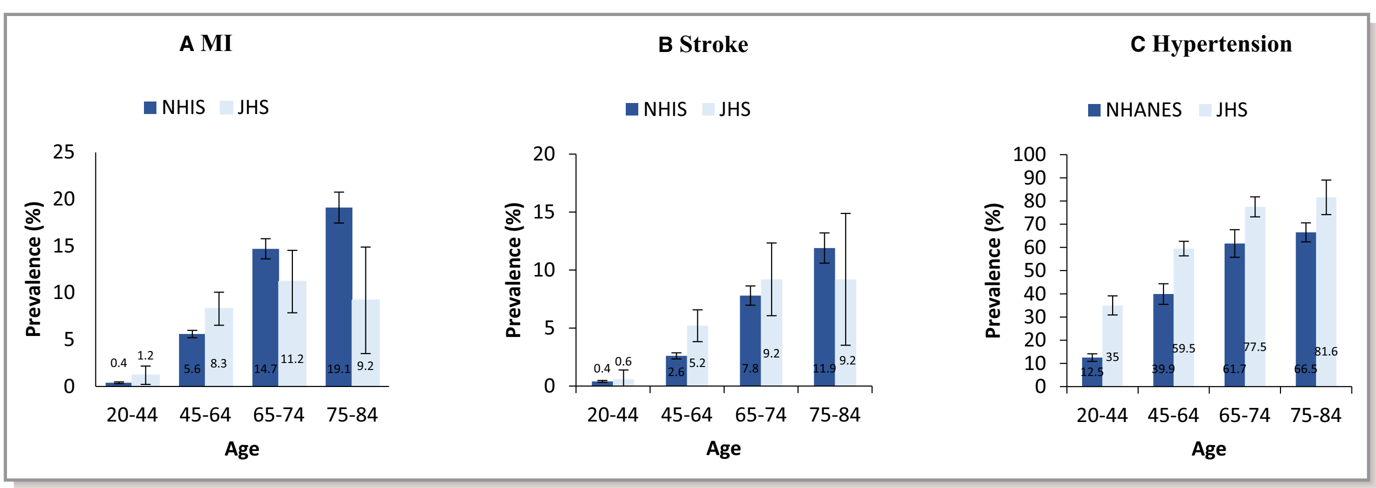

Figure 1. Age-specific prevalence in men. Population estimates vs the JHS: (A) MI, (B) stroke, and (C) hypertension. JHS indicates Jackson Heart Study; MI, myocardial infarction; NHANES, National Health and Nutrition Examination Survey; NHIS, National Health Interview Survey.

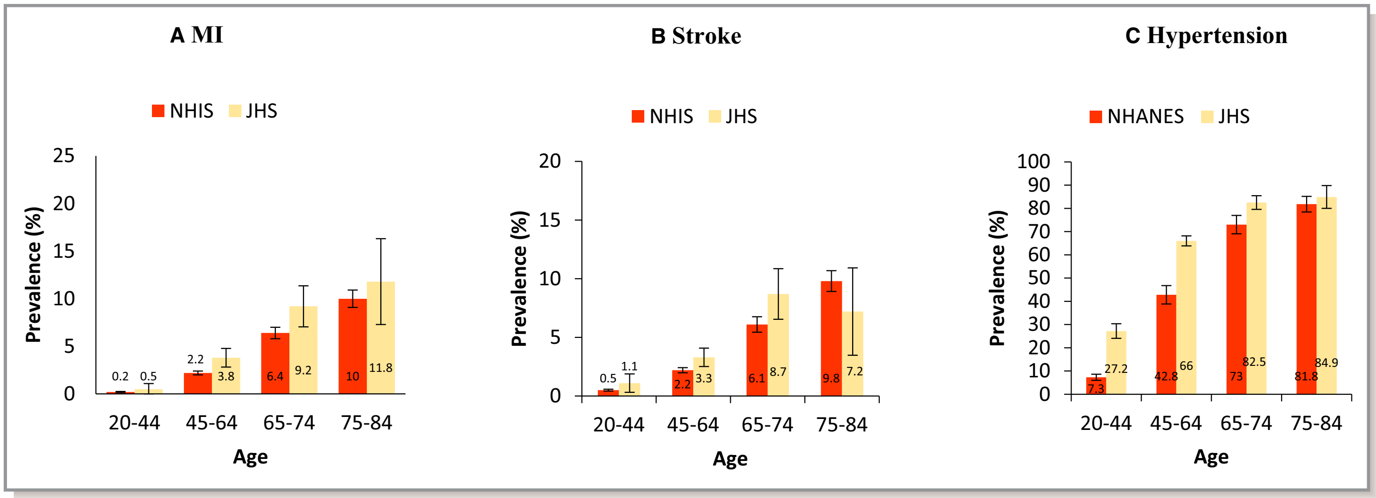

Figure 2. Age-specific prevalence in women. Population estimates vs the JHS: (A) MI, (B) stroke, and (C) hypertension. JHS indicates Jackson Heart Study; MI, myocardial infarction; NHANES, National Health and Nutrition Examination Survey; NHIS, National Health Interview Survey.

men was very close to 1 and did not reach statistical significance. In contrast, the SPR for MI in women was 50% higher than expected (SPR: 1.50; 95% CI, 1.27–1.76). The prevalence of stroke was 46% higher than expected in men (SPR: 1.46; 95% CI, 1.18–1.78) and 33% higher than expected in women (SPR: 1.33; 95% CI, 1.12–1.57). The prevalence of hypertension was 51% higher than expected in men (SPR: 1.51; 95% CI, 1.42–1.60) and 43% higher than expected in women (SPR: 1.43; 95% CI, 1.37–1.50).

CVD Burden and SES Correlates

The prevalence of MI, stroke, and hypertension by education, income, and occupation in the JHS are shown in Table 3. As expected, the prevalence of MI, stroke, and hypertension was significantly patterned by each SES measure in a dose-response manner: Lower educational attainment, lower income, and nonprofessional or nonmanagement jobs were all associated with higher prevalence of MI, stroke, and hypertension (versus their respective higher status counterparts).

In the age- and sex-adjusted analyses (Tables 4 through 6; model 1), the effect of SES on prevalent MI, stroke, and hypertension remained statistically significant. In general, the effect of SES tended to be stronger for MI and stroke than for hypertension. In addition, the effect size of occupation tends to be smaller than that of education or income. After adjusting for age and sex, for example, the odds of having a history of MI or stroke was >3-fold higher among poor participants than among affluent participants, whereas the odds of being hypertensive among poor participants was only 50% higher than among affluent participants. Nonetheless, it should be noted that the prevalence was substantially higher for hypertension than for MI or stroke (ie, the absolute burden was greater). Adjusting for LSS score did not change the previously observed relationship of prevalent CVD with income; however, the associations with education and occupation were somewhat attenuated (Tables 4 through 6; model 2). Further analyses were performed to examine the relative importance of the SES variables and CVD by including all 3 SES variables with age, sex, and LSS score in the regression models. Although education may be thought of as a more robust SES variable than either income or occupation, in our analysis, education was no longer statistically significantly associated with prevalent CVD after accounting for income and occupation (Tables 4 through 6; model 3). Indeed, using a backward selection procedure, the only SES variable that was consistently dropped out of the models was education. In the final models using backward selection, only income was significantly associated with prevalent stroke (P=0.0017) and hypertension (P=0.0029), and income (P=0.0013) and occupation (P=0.0091) were significantly associated with prevalent MI (Table 7).

Subgroup Analysis

In addition to the age- and sex-adjusted analyses shown, subgroup analyses were performed stratified by age (<65 versus ≥65 years; Table S1) and by sex (Table S2). The associations between SES and prevalent CVD were consistent between the 2 age groups and between men and women. Although there was a suggestion of a stronger effect of SES in younger than in older age groups and in women than in men, only the sex×occupation interactions on prevalent MI were statistically significant (P=0.0372 for interaction).

Table 2. JHS Prevalence and SPR* for MI, Stroke, and Hypertension, by Sex and Overall

CVD Outcomes	n	Prevalence, % (95% CI)	SPR (95% CI)
MI			
Male	1934	7.1 (5.9–8.2)	1.07 (0.90–1.27)
Female	3367	4.5 (3.8–5.2)	1.50 (1.27–1.76)
Total	5301	5.5 (4.9–6.1)	1.26 (1.12–1.42)
Stroke			
Male	1934	5.0 (4.0–6.0)	1.46 (1.18–1.78)
Female	3367	4.1 (3.4–4.7)	1.33 (1.12–1.57)
Total	5301	4.4 (3.9–5.0)	1.38 (1.21–1.57)
Hypertension			
Male	1934	57.6 (55.4–59.8)	1.51 (1.42–1.60)
Female	3367	61.6 (60.0–63.2)	1.43 (1.37–1.50)
Total	5301	60.1 (58.8–61.5)	1.46 (1.41–1.51)

CI indicates confidence interval; CVD, cardiovascular disease; JHS, Jackson Heart Study; MI, myocardial infarction; SPR, standardized prevalence ratio.
*Comparing the observed prevalence in the JHS and the expected prevalence based on US population estimates. SPRs were age-adjusted for the sex-specific results and sex- and age-adjusted for the overall results.

Discussion

Our study showed that despite comparable SES characteristics between the JHS cohort and the US population, the JHS cohort bears a significantly higher burden of prevalent MI, stroke, and hypertension. These results suggest that the observed racial/ethnic disparity in CVD burden may not be entirely explained by SES. We were unable to evaluate factors contributing to racial/ethnic disparity directly because the JHS cohort is exclusively black; however, given our findings, we believe it is reasonable to postulate that the racial/ethnic disparity in CVD burden may be attributed to other factors in addition to lower SES among black persons. Researchers have hypothesized that negative psychosocial factors and stress unique to those of black race may have a significant impact on health outcomes. Many of these factors have been investigated in the JHS. Indeed, perceived discrimination has been positively associated with hypertension[17] and health behaviors[8] in the JHS. Furthermore, depressive symptoms have also been positively associated with incident stroke and coronary heart disease[18] among black participants in the JHS. Depressive symptoms were found to be positively associated with incident coronary heart disease or revascularization among black but not white participants in the REGARDS (Reasons for Geographical and Racial Differences in Stroke) study.[19] Moreover, racial/ethnic residential segregation has been suggested to have a detrimental effect on CVD outcomes that is greater in black populations than in other racial/ethnic groups.[20]

In addition, within the JHS, we observed an inverse gradient of prevalent CVD in relation to SES. Prior studies

Table 3. Prevalence of MI, Stroke, and Hypertension by SES

SES Indicators	n	MI, n (%)	Stroke, n (%)	Hypertension, n (%)
Education				
College graduate	1714	52 (3.03)	40 (2.33)	931 (54.32)
Some college	1518	62 (4.08)	55 (3.62)	824 (54.28)
High school graduate	974	61 (6.26)	38 (3.90)	618 (63.45)
Less than high school	1075	114 (10.60)	101 (9.40)	804 (74.79)
P value		<0.0001	<0.0001	<0.0001
Income				
Affluent	1358	38 (2.80)	29 (2.14)	740 (54.49)
Upper middle	1325	57 (4.30)	46 (3.47)	768 (57.96)
Lower middle	1097	73 (6.65)	68 (6.20)	718 (65.45)
Poor	701	66 (9.42)	58 (8.27)	455 (64.91)
P value		<0.0001	<0.0001	<0.0001
Occupation				
Professional/management	1881	77 (4.09)	59 (3.14)	1050 (55.82)
Service/sales	2206	105 (4.76)	104 (4.71)	1369 (62.06)
Construction/production	1106	100 (9.04)	67 (6.06)	705 (63.74)
P value		<0.0001	0.0006	<0.0001

P values were calculated using χ^2 tests. MI indicates myocardial infarction; SES, socioeconomic status.

Table 4. Adjusted ORs of Prevalent Myocardial Infarction by SES*

SES Variable	Model 1, OR (95% CI)	Model 2, OR (95% CI)	Model 3, OR (95% CI)
Education			
College graduate (Ref)	1.00	1.00	1.00
Some college	1.56 (1.07, 2.28)	1.27 (0.82, 1.96)	1.09 (0.64, 1.87)
High school graduate	1.90 (1.29, 2.78)	1.61 (1.04, 2.49)	1.29 (0.71, 2.35)
Less than high school	2.25 (1.57, 3.21)	1.85 (1.23, 2.78)	1.60 (0.87, 2.93)
P value	0.0001	0.0224	0.3989
Income			
Affluent (Ref)	1.00	1.00	1.00
Upper middle	1.69 (1.11, 2.58)	1.88 (1.17, 3.04)	1.77 (1.08, 2.92)
Lower middle	2.07 (1.37, 3.12)	1.98 (1.23, 3.20)	1.77 (1.03, 3.04)
Poor	3.53 (2.31, 5.40)	3.08 (1.85, 5.13)	2.68 (1.49, 4.84)
P value	<0.0001	0.0003	0.0114
Occupation			
Professional/management (Ref)	1.00	1.00	1.00
Service/sales	1.08 (0.79, 1.47)	0.87 (0.61, 1.24)	0.57 (0.35, 0.91)
Construction/production	1.79 (1.29, 2.48)	1.51 (1.04, 2.18)	1.03 (0.62, 1.72)
P value	0.0007	0.0113	0.0067

P values were calculated using Wald χ^2 tests. CI indicates confidence interval; LSS, Life's Simple Seven; OR, odds ratio; Ref, reference group; SES, socioeconomic status.
*Model 1: age and sex adjusted; model 2: age, sex, and LSS score adjusted; model 3: age, sex, LSS score, and SES adjusted. In model 3, the associations between 1 SES variable and prevalent event were adjusted for the other 2 SES variables in the model.

have suggested that the strongest socioeconomic effects are within the white population[21] and that the SES gradient of CVD risk and risk factors may be diminished in black populations, possibly due to influences of discrimination, residential segregation, and psychosocial factors across all SES levels.[22,23] In our study, all 3 SES variables—income, education, and occupation—were highly associated with prevalent CVD. These associations were found to be consistent between older and younger age groups and between men and women, with a suggestion of a possibly stronger effect in the younger age group and in women. A stronger SES effect in younger than older age groups may be expected because biological changes in old age may contribute more to disease processes than does SES.[21,24] These findings are largely in agreement with the findings by Gebreab et al[25] regarding the impact of lifetime socioeconomic position on new and recurrent CVD events in the JHS. In that study, the authors found a positive association between CVD events and adult socioeconomic position. They also observed a stronger effect of socioeconomic position in younger than older participants, and the effect was more consistent in women than in men. Karlamangla et al[23] also found a strong inverse socioeconomic gradient with cardiovascular risks using data from the National Health and Nutrition Examination Survey (2001–2006) and attributed racial/ethnic disparities in cardiovascular risks in the United States primarily to disparities in SES.

Although disagreements exist about which SES indicator is more important in relation to health outcomes in the United States,[26–28] in our study, income emerged as the most important SES correlate for prevalent CVD (MI, stroke, and hypertension). Gebreab et al[25] also reported a less consistent association between education and new and recurrent CVD in the JHS. Furthermore, Crimmins et al[21] reported that, in general, education does not significantly relate to the prevalence of disease among black and Hispanic persons. A possible reason may be that higher educational attainment in minority populations does not necessarily lead to higher earning power. Another possible reason may be access to health care.[29] Because income is a known determinant of access to health care, these findings may suggest that access to health care plays an important role in cardiovascular health in minority populations, perhaps mediating by reducing the burden of cardiovascular risk factors. Moreover, our study suggested that occupation was an important SES correlate for MI, independent of the effect of income in the backward selection analysis, and that the effect appeared to be primarily due to the effect on women (a significant interaction between sex and occupation). Although occupation was used as an indicator of SES, occupations represented in lower SES often have worse working conditions and greater job insecurity.[30,31] Given a greater excess burden of MI observed in women than men among the JHS participants compared with the US

Table 5. Adjusted ORs of Prevalent Stroke by SES*

SES Variables	Model 1, OR (95% CI)	Model 2, OR (95% CI)	Model 3, OR (95% CI)
Education			
College graduate (Ref)	1.00	1.00	1.00
Some college	1.82 (1.20–2.77)	1.35 (0.85–2.14)	1.22 (0.74–2.13)
High school graduate	1.47 (0.93–2.32)	1.12 (0.67–1.84)	1.02 (0.53–1.96)
Less than high school	2.49 (1.68–3.70)	1.89 (1.23–2.92)	1.68 (0.81–3.16)
P value	<0.0001	0.0176	0.2010
Income			
Affluent (Ref)	1.00	1.00	1.00
Upper middle	1.74 (1.08–2.80)	1.49 (0.90–2.46)	1.41 (0.83–2.38)
Lower middle	2.36 (1.50–3.72)	1.57 (0.96–2.58)	1.41 (0.80–2.50)
Poor	3.73 (2.32–5.97)	2.69 (1.60–4.52)	2.45 (1.34–4.50)
P value	<0.0001	0.0020	0.0198
Occupation			
Professional/management (Ref)	1.00	1.00	1.00
Service/sales	1.38 (0.99–1.92)	1.07 (0.74–1.54)	0.73 (0.45–1.18)
Construction/production	1.58 (1.08–2.30)	1.34 (0.88–2.03)	0.86 (0.49–1.50)
P value	0.0453	0.3688	0.4057

P values were calculated using Wald χ^2 tests. CI indicates confidence interval; LSS, Life's Simple Seven; OR, odds ratio; Ref, reference group; SES, socioeconomic status.
*Model 1: age and sex adjusted; model 2: age, sex, and LSS score adjusted; model 3: age, sex, LSS score, and SES adjusted. In model 3, the associations between 1 SES variable and prevalent event were adjusted for the other 2 SES variables in the model.

population, further studies into possible effects of occupational factors in women, such as occupational stress, job strain, and shift work,[32,33] on MI may provide useful insights into preventive measures for MI in the workplace.

This study has many strengths, but several potential limitations to the interpretation of our findings must be considered. A limitation of our study is that household income appeared to be somewhat lower in the JHS cohort than in the US population. Although we expect that the lower household income in the JHS cohort may, in part, be attributable to the cohort having more women and participants aged ≥65 years than the US population, we were unable to demonstrate this with the available data because the characteristics of householders (ie, heads of households) and the type of households that are used to report US household incomes were not collected in the JHS. Given that the distributions of personal income were remarkably similar between the JHS cohort and the US population and that mean household size was similar (2.64 in the JHS versus 2.60 in the United States), we believe it is reasonable to conclude that the SES of the JHS cohort was comparable to that of the US population. Nevertheless, it remains possible that the higher burden of CVD that we observed in the JHS cohort could be a result of uncontrolled confounding by SES. Another limitation is that this was a single-site study in 1 geographic location, thus the results may not be generalizable to other geographic locations. It is also possible that the excess CVD burden is in part the result of this geographic location. Notably, the "Stroke belt" in the southeastern regions of the United States, with an unexplained excess risk of stroke mortality, has long been recognized,[34] and others have associated the "Southern" diet pattern with a high risk of acute coronary heart disease.[35] Given that the Southern diet pattern is associated with low SES[35] and that low SES may be a contributing factor to the Stroke belt phenomena,[36] our analysis of a population with SES comparable to that of the US population may limit the effects of these factors on our findings. Furthermore, in an analysis of regional black–white differences in stroke risk, Howard et al[36] reported that an excess of stroke mortality was present in black participants in both southern and nonsouthern states and that the excess was larger than expected in southern states, suggesting that the higher risk for black persons may be independent of the causes contributing to the Stroke belt. In addition, the analysis is cross-sectional. In our analyses, we did not see an excess burden of prevalent MI in men. This finding may suggest a similar burden of MI in the JHS and the reference population, or alternatively, it may be due to survival bias resulting from higher mortality from MI in our target population. Furthermore, given the cross-sectional nature of the analysis, the directionality of a causal effect of SES on CVD burden may not be established unequivocally. Nevertheless, as we noted

Table 6. Adjusted ORs of Prevalent Hypertension by SES*

SES Variables	Model 1, OR (95% CI)	Model 2, OR (95% CI)	Model 3, OR (95% CI)
Education			
College graduate (Ref)	1.00	1.00	1.00
Some college	1.27 (1.09, 1.48)	1.20 (1.01, 1.42)	1.13 (0.92, 1.38)
High school graduate	1.27 (1.07, 1.52)	1.24 (1.01, 1.51)	1.09 (0.84, 1.41)
Less than high school	1.24 (1.03, 1.49)	1.18 (0.95, 1.46)	1.10 (0.81, 1.48)
P value	0.0044	0.0801	0.7323
Income			
Affluent (Ref)	1.00	1.00	1.00
Upper middle	1.27 (1.08, 1.50)	1.28 (1.07, 1.54)	1.20 (0.99, 1.46)
Lower middle	1.24 (1.03, 1.48)	1.18 (0.96, 1.44)	1.06 (0.85, 1.33)
Poor	1.51 (1.22, 1.87)	1.51 (1.18, 1.93)	1.38 (1.04, 1.83)
P value	0.0006	0.0041	0.0667
Occupation			
Professional/management (Ref)	1.00	1.00	1.00
Service/sales	1.25 (1.09, 1.43)	1.20 (1.03, 1.40)	1.13 (0.93, 1.37)
Construction/production	1.26 (1.06, 1.50)	1.19 (0.98, 1.45)	1.12 (0.87, 1.45)
P value	0.0018	0.0382	0.4349

P values were calculated using Wald χ^2 tests. CI indicates confidence interval; LSS, Life's Simple Seven; OR, odds ratio; Ref, reference group; SES, socioeconomic status.
*Model 1: age and sex adjusted; model 2: age, sex, and LSS score adjusted; model 3: age, sex, LSS score, and SES adjusted. In model 3, the associations between 1 SES variable and prevalent event were adjusted for the other 2 SES variables in the model.

earlier, similar findings were reported by Gebreab et al,[25] who evaluated the associations between SES and CVD using incident and recurrent CVD events collected longitudinally in the JHS, suggesting the robustness of the results of this study. Still, most studies have found that the effect of health on SES indicators is not as important as the effect of SES indicators on health,[21] which led us to conclude that reverse causality in our study is unlikely. Furthermore, coding of

Table 7. Final Models After Backward Selection Procedures

Variables	MI, OR (95% CI)	*P* Value	Stroke, OR (95% CI)	*P* Value	Hypertension, OR (95% CI)	*P* Value
Age, y	1.05 (1.03–1.06)	<0.0001	1.06 (1.04–1.07)	<0.0001	1.07 (1.06–1.07)	<0.0001
Sex (male)	1.84 (1.29–2.62)	0.0007	1.47 (1.04–2.07)	0.0412	0.92 (0.79–1.08)	0.9718
LSS score	0.68 (0.57–0.80)	<0.0001	0.73 (0.61–0.87)	0.0003	0.73 (0.68–0.80)	<0.0001
Education	...	...	...	...	...	...
Income						
Affluent	1.00	0.0013	1.00	0.0017	1.00	0.0029
Upper middle	1.87 (1.15–3.04)		1.46 (0.88–2.41)		1.28 (1.06–1.54)	
Lower middle	2.00 (1.20–3.34)		1.55 (0.94–2.55)		1.18 (0.96–1.44)	
Poor	3.08 (1.77–5.37)		2.72 (1.62–4.59)		1.56 (1.21–2.00)	
Occupation						
Professional/management	1.00	0.0091	...	...	...	...
Service/sales	0.66 (0.43–1.00)		...		...	
Construction/production	1.24 (0.80–1.92)		...		...	

P values were calculated using Wald chi-square tests. Ellipses indicate that the variable was not retained in the model. Age, sex, and LSS score were forced into the model. CI indicates confidence interval; LSS, Life's Simple Seven; MI, myocardial infarction; OR, odds ratio.

occupations was based on reported jobs of the participants if they were employed or on last jobs held if they were unemployed or retired at the baseline exam. As such, the SES of the participants may not be accurately reflected by their assigned occupation categories; however, given that JHS participants were mostly in middle age (mean age: 55 years), it might be reasonable to assume that their current jobs or last jobs held were representative of their occupational exposures and relative social standings.

Our analyses were performed using complete cases and, as such, may lead to biased results. About 15% of the participants were missing data on income. Compared with participants with income data, participants without income data appeared to be somewhat less educated and less likely to have management/professional jobs but otherwise were similar in the distributions of age, sex, CVD prevalence, and LSS scores. Given that missingness of income was not associated with the end points (prevalent CVD), it is unlikely that it would have biased the observed association between SES and prevalent CVD. Sensitivity analyses using multiple imputations assuming data were missing at random, while somewhat attenuated the magnitudes of the effects, did not change the observed associations (Table S3). The strongest and most consistent socioeconomic correlate after adjusting for age and sex was income for MI (odds ratio: 2.85; 95% CI, 1.90–4.28) and stroke (odds ratio: 3.15; 95% CI, 2.01–4.94), comparing the poor and affluent income categories.

Finally, we should note that we did not evaluate the burden of heart failure in this study because no reliable national estimates of heart failure prevalence corresponding to the JHS baseline exam period were available. Given that heart failure prevalence is increasing in the United States and racial/ethnic disparities exists in heart failure incidence,[37] heart failure should be considered when evaluating CVD burden and racial/ethnic disparity in CVD burden.

In conclusion, we found a higher CVD burden in a black population compared with the US general population, despite similar distributions of SES. Furthermore, an inverse socioeconomic gradient of CVD burden exists in a black population with a well-represented SES spectrum. Income, in particular, is an important contributor to disparities in the burden of CVD among black persons. Because the JHS is a cohort of exclusively black participants, we were unable to evaluate factors contributing to racial/ethnic disparity directly. Nonetheless, given our findings, we believe it is reasonable to postulate that the racial/ethnic disparities in CVD burden may be attributable to other factors in addition to lower SES among black populations. These factors may include higher burden of traditional risk factors in black persons across the SES spectrum. Other factors may include social determinants of health specific to black persons such as discrimination, stress, and residential segregation.

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Disclosures

None.

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SUPPLEMENTAL MATERIAL

Table S1. Odds Ratios (OR) of Prevalent MI, Stroke and Hypertension by SES: Stratified Analysis by Age (Sex and LSS Score-Adjusted)

	MI OR (95% CI)			Stroke OR (95% CI)			Hypertension OR (95% CI)		
SES Variables	**< 65 years**	**≥ 65 years**	**P-value for Interaction**	**< 65 years**	**≥ 65 years**	**P-value for Interaction**	**< 65 years**	**≥ 65 years**	**P-value for Interaction**
Education									
College graduate (Ref)	1.00	1.00	*0.0812*	1.00	1.00	*0.6562*	1.00	1.00	*0.1114*
Some College	1.17 (0.69, 1.99)	1.19 (0.56, 2.53)		1.00 (0.58, 1.71)	2.06 (0.85, 4.97)		0.98 (0.83, 1.17)	1.14 (0.67, 1.93)	
HS graduate	1.78 (1.02, 3.09)	1.37 (0.68, 2.76)		1.05 (0.57, 1.95)	1.53 (0.63, 3.74)		1.37 (1.11, 1.69)	0.87 (0.54, 1.39)	
< HS	3.32 (1.93, 5.70)	1.42 (0.78, 2.58)		2.03 (1.13, 3.64)	2.92 (1.41, 6.07)		1.58 (1.22, 2.04)	1.20 (0.80, 1.80)	
P-value	*<0.0001*	*0.6839*		*0.0600*	*0.0149*		*<0.0001*	*0.4733*	

SES Variables	MI OR (95% CI) < 65 years	MI OR (95% CI) ≥ 65 years	MI P-value for Interaction	Stroke OR (95% CI) < 65 years	Stroke OR (95% CI) ≥ 65 years	Stroke P-value for Interaction	Hypertension OR (95% CI) < 65 years	Hypertension OR (95% CI) ≥ 65 years	Hypertension P-value for Interaction
Income									
Affluent (Ref)	1.00	1.00	*0.9672*	1.00	1.00	*0.5714*	1.00	1.00	*0.9476*
Upper-middle	1.70 (0.95, 3.04)	2.04 (0.89, 4.71)		1.42 (0.79, 2.56)	1.49 (0.59, 3.76)		1.11 (0.91, 1.34)	1.20 (0.72, 1.98)	
Lower-middle	2.13 (1.15, 3.96)	2.11 (0.97, 4.59)		1.28 (0.65, 2.52)	2.40 (1.06, 5.40)		1.13 (0.91, 1.41)	1.27 (0.81, 2.00)	
Poor	3.05 (1.58, 5.90)	3.21 (1.40, 7.36)		2.19 (1.11, 4.35)	4.03 (1.72, 9.46)		1.23 (0.94, 1.60)	1.51 (0.87, 2.62)	
P-value	*0.0081*	*0.0528*		*0.1586*	*0.0044*		*0.4126*	*0.5182*	

	MI OR (95% CI)			Stroke OR (95% CI)			Hypertension OR (95% CI)		
SES Variables	**< 65 years**	**≥ 65 years**	**P-value for Interaction**	**< 65 years**	**≥ 65 years**	**P-value for Interaction**	**< 65 years**	**≥ 65 years**	**P-value for Interaction**
Occupation									
Professional/ Management (Ref)	1.00	1.00	*0.1013*	1.00	1.00	*0.8852*	1.00	1.00	*0.1289*
Service/ Sales	1.01 (0.63, 1.64)	0.72 (0.43, 1.22)		1.00 (0.62, 1.62)	1.24 (0.70, 2.19)		1.18 (1.00, 1.38)	0.90 (0.62, 1.32)	
Other	2.09 (1.24, 3.38)	1.06 (0.60, 1.86)		1.29 (0.74, 2.26)	1.57 (0.84, 2.94)		1.33 (1.08, 1.65)	0.82 (0.58, 1.27)	
P-value	*0.0028*	*0.3402*		*0.6115*	*0.3677*		*0.0165*	*0.6689*	

Table S2. Odds Ratios (OR) of Prevalent MI, Stroke and Hypertension by SES: Stratified Analysis by Sex (Age and LSS Score-Adjusted)

	MI OR (95% CI)			Stroke OR (95% CI)			Hypertension OR (95% CI)		
SES Variables	**Male**	**Female**	**P-value for Interaction**	**Male**	**Female**	**P-value for Interaction**	**Male**	**Female**	**P-value for Interaction**
Education									
College graduate (Ref)	1.00	1.00	*0.0669*	1.00	1.00	*0.4916*	1.00	1.00	*0.4143*
Some College	1.71 (0.95, 3.08)	0.88 (0.45, 1.71)		1.16 (0.54, 2.50)	1.46 (0.82, 2.61)		1.09 (0.82, 1.45)	1.27 (1.03, 1.56)	
HS graduate	1.87 (1.01, 3.47)	1.41 (0.76, 2.60)		1.48 (0.68, 3.21)	0.94 (0.48, 1.82)		1.16 (0.83, 1.61)	1.28 (1.00, 1.63)	
< HS	1.48 (0.81, 2.79)	2.15 (1.22, 3.77)		1.96 (1.00, 3.86)	1.82 (1.04, 3.21)		0.98 (0.70, 1.38)	1.33 (1.01, 1.75)	
P-value	*0.1918*	*0.0114*		*0.2307*	*0.0707*		*0.7916*	*0.0556*	

	MI OR (95% CI)			Stroke OR (95% CI)			Hypertension OR (95% CI)		
SES Variables	**Male**	**Female**	**P-value for Interaction**	**Male**	**Female**	**P-value for Interaction**	**Male**	**Female**	**P-value for Interaction**
Income									
Affluent (Ref)	1.00	1.00	*0.4459*	1.00	1.00	*0.3658*	1.00	1.00	*0.3630*
Upper-middle	1.67 (0.90, 3.10)	2.26 (1.04, 4.93)		1.57 (0.76, 3.22)	1.41 (0.70, 2.85)		1.32 (0.99, 1.28)	1.27 (1.00, 1.61)	
Lower-middle	1.60 (0.84, 3.08)	2.49 (1.16, 5.35)		1.17 (0.54, 2.55)	1.77 (0.91, 3.46)		1.05 (0.75, 1.81)	1.25 (0.97, 1.61)	
Poor	3.77 (1.89, 7.54)	3.00 (1.35, 6.66)		3.80 (1.75, 8.26)	2.32 (1.15, 4.67)		1.17 (0.76, 1.81)	1.69 (1.25, 2.28)	
P-value	*0.0025*	*0.0571*		*0.0044*	*0.1039*		*0.2948*	*0.0069*	

	MI OR (95% CI)			Stroke OR (95% CI)			Hypertension OR (95% CI)		
SES Variables	**Male**	**Female**	**P-value for Interaction**	**Male**	**Female**	**P-value for Interaction**	**Male**	**Female**	**P-value for Interaction**
Occupation									
Professional/ Management (Ref)	1.00	1.00	*0.0372*	1.00	1.00	*0.9810*	1.00	1.00	*0.7520*
Service/ Sales	0.61 (0.34, 1.09)	1.15 (0.72, 1.86)		1.00 (0.51, 1.96)	1.11 (0.71, 1.74)		1.08 (0.82, 1.44)	1.25 (1.04, 1.50)	
Other	1.03 (0.65, 1.64)	2.54 (1.44, 4.49)		1.29 (0.72, 2.30)	1.36 (0.73, 2.53)		1.17 (0.90, 1.53)	1.17 (0.86, 1.58)	
P-value	*0.1468*	*0.0022*		*0.5992*	*0.6331*		*0.5118*	*0.0534*	

Table S3. Multiple Imputations: Adjusted Odds Ratios (OR) of Prevalent MI, Stroke and Hypertension by SES

	Model 1 Age and sex-adjusted			Model 2 Age, sex and LSS-adjusted			Model 3 Age, sex, LSS and SES-adjusted*		
SES Variables	**MI OR (95% CI)**	**Stroke OR (95% CI)**	**HTN OR (95% CI)**	**MI OR (95% CI)**	**Stroke OR (95% CI)**	**HTN OR (95% CI)**	**MI OR (95% CI)**	**Stroke OR (95% CI)**	**HTN OR (95% CI)**
Education									
College graduate (Ref)	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Some College	1.56 (1.07, 2.28)	1.82 (1.20, 2.76)	1.27 (1.09, 1.47)	1.45 (0.99, 2.13)	1.70 (1.12, 2.58)	1.21 (1.03, 1.40)	1.35 (0.88, 2.09)	1.46 (0.91, 2.35)	1.11 (0.93, 1.31)
HS graduate	1.90 (1.30, 2.79)	1.46 (0.93, 2.31)	1.27 (1.07, 1.52)	1.74 (1.18, 2.56)	1.35 (0.85, 2.13)	1.19 (1.00, 1.42)	1.55 (0.96, 2.52)	1.10 (0.64, 1.91)	1.06 (0.86, 1.31)
< HS	2.26 (1.58, 3.23)	2.48 (1.67, 3.69)	1.23 (1.02, 1.49)	2.07 (1.44, 2.97)	2.29 (1.54, 3.41)	1.14 (0.94, 1.37)	1.72 (1.05, 2.81)	1.71 (1.00, 2.90)	0.98 (0.77, 1.25)

	Model 1 Age and sex-adjusted			Model 2 Age, sex and LSS-adjusted			Model 3 Age, sex, LSS and SES-adjusted*		
SES Variables	**MI OR (95% CI)**	**Stroke OR (95% CI)**	**HTN OR (95% CI)**	**MI OR (95% CI)**	**Stroke OR (95% CI)**	**HTN OR (95% CI)**	**MI OR (95% CI)**	**Stroke OR (95% CI)**	**HTN OR (95% CI)**
Income									
Affluent (Ref)	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Upper-middle	1.55 (1.93, 2.34)	1.61 (1.04, 2.50)	1.23 (1.04, 1.46)	1.46 (0.96, 2.22)	1.53 (0.98, 2.38)	1.18 (1.00, 1.40)	1.34 (0.87, 2.08)	1.42 (0.90, 2.25)	1.13 (0.95, 1.36)
Lower-middle	1.79 (1.21, 2.66)	2.09 (1.37, 3.19)	1.19 (1.00, 1.43)	1.69 (1.13, 2.53)	1.99 (1.30, 3.04)	1.13 (0.94, 1.36)	1.47 (0.93, 2.33)	1.73 (1.07, 2.79)	1.06 (0.86, 1.31)
Poor	2.85 (1.90, 4.28)	3.15 (2.01, 4.94)	1.40 (1.14, 1.71)	2.64 (1.74, 4.01)	2.94 (1.86, 4.64)	1.30 (1.06, 1.60)	2.24 (1.38, 3.64)	2.49 (1.47, 4.22)	1.22 (0.97, 1.55)

	Model 1 Age and sex-adjusted			Model 2 Age, sex and LSS-adjusted			Model 3 Age, sex, LSS and SES-adjusted*		
SES Variables	**MI** **OR** **(95% CI)**	**Stroke** **OR** **(95% CI)**	**HTN** **OR** **(95% CI)**	**MI** **OR** **(95% CI)**	**Stroke** **OR** **(95% CI)**	**HTN** **OR** **(95% CI)**	**MI** **OR** **(95% CI)**	**Stroke** **OR** **(95% CI)**	**HTN** **OR** **(95% CI)**
Occupation									
Professional/ Management (Ref)	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Service/ Sales	1.08 (0.79, 1.48)	1.36 (0.98, 1.90)	1.24 (1.08, 1.42)	1.02 (0.75, 1.39)	1.29 (0.93, 1.80)	1.19 (1.03, 1.37)	0.66 (0.45, 0.96)	0.83 (0.55, 1.25)	1.12 (0.95, 1.32)
Other	1.77 (1.28, 2.44)	1.55 (1.07, 2.26)	1.25 (1.05, 1.48)	1.66 (1.20, 2.30)	1.47 (1.01, 2.14)	1.17 (0.99, 1.40)	1.00 (0.66, 1.50)	0.89 (0.57, 1.41)	1.10 (0.89, 1.35)

*The associations (ORs) between one SES variable and prevalent CVD were adjusted for the other two SES variables in the model.