# Socioeconomic Status is Related to Urinary Catecholamines in the Coronary Artery Risk Development in Young Adults (CARDIA) Study

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**Objective:** To determine whether socioeconomic status (SES) is associated with catecholamine levels (epinephrine [E] and norepinephrine [NE]—indicators of sympathetic nervous system [SNS] activity) in a community-based sample of men and women, Blacks and Whites, with a broad range of income; and to test whether such a relationship is mediated by psychosocial factors and/or health behaviors. **Methods:** A total of 672 participants from the Coronary Artery Risk Development in Young Adults study (CARDIA) provided 12-hour, overnight urine samples, and completed sociodemographic, health behavior, and psychosocial questionnaires. **Results:** Regardless of whether measured in terms of income, education, or occupation, higher SES was associated with lower urinary catecholamine levels, independent of age, race, and gender. These relationships were stronger in men than in women but were similar across Blacks and Whites. Smoking and greater levels of depressive symptoms accounted for some of the association of SES with E and, to a lesser extent, with NE. **Conclusions:** These data provide support for the hypothesis that lower SES is accompanied by increased physiologic distress, indicated by elevated SNS activity. Further, they suggest that the association of SES with catecholamines, like the associations of SES with morbidity and mortality, is apparent at all levels of the socioeconomic hierarchy. **Key words:** socioeconomic status, catecholamines, sympathetic nervous system, CARDIA, health behaviors.

**SES** = socioeconomic status; **SNS** = sympathetic nervous system; **E** = epinephrine; **NE** = norepinephrine; **CARDIA** = Coronary Artery Risk Development in Young Adults study; **BMI** = body mass index.

## INTRODUCTION

Research conducted over the past 20 years describes a graded association between socioeconomic status (SES) and health that occurs at every level of the socioeconomic hierarchy (1). Although the prevalence of health-risk behaviors such as smoking, poor diet, and physical inactivity increase with decreasing SES, these factors alone do not explain the graded association between SES and health (2). Thus, it is important to identify additional mechanisms by which the experience of relative SES disadvantage may be translated into physical disease outcomes.

An alternative pathway by which SES may influence health is by stimulating the sympathetic nervous system (SNS) via the release of excess catecholamines (epinephrine [E] and norepinephrine [NE]). Although acute increases in circulating catecholamines are adaptive, prolonged exposure to elevated levels of these hormones can be pathogenic (3). Catecholamines typically have been labeled as "stress" hormones. However, some have argued that psychosocial factors other than stress can influence catecholamine secretion. Inadequate social resources and low self-efficacy, for example, which increase with decreasing SES (4), may be two such factors. Moreover, certain health behaviors that vary with SES, such as smoking and obesity, also can affect the release of catecholamines.

A few studies have examined differences in catecholamine concentrations according to the level of SES, and results have been mixed. A comparison of 8- to 10-year-olds from low- and middle-income families showed that low-income children had higher E levels relative to their middle-income peers. The two groups did not differ on the levels of NE (5). Additional studies conducted with adult samples have found low SES to be related to higher levels of allostatic load, an aggregate measure of biological stress that includes catecholamine levels (6–9). However, the one study that examined the relationship of SES with individual components of allostatic load found no relationship between SES and catecholamines (10). Because the latter study was conducted among an older Taiwanese sample, it is possible that cultural differences in how SES was defined may have obscured the results.

By comparison, a study conducted in the United States in a low SES sample (median income of approximately $20,000) showed that lower SES was associated in a graded fashion with higher E and marginally higher NE, independent of age, race, gender, and body mass (11). It was unclear, however, whether the same relationships would hold across populations with a broader span of income, including incomes in the higher range of the distribution. Also, the sample employed by Cohen et al. (11) was unique in that eligibility for the study depended on the participants' availability to be quarantined in a hotel for 5 days postexposure to an upper respiratory virus. In other words, individuals who were both willing and able to submit themselves to the demanding protocol of the parent study were no doubt distinct from average members of the population.

Here we reexamine the association of SES and catecholamines using data from the Coronary Artery Risk De-

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velopment in Young Adults study (CARDIA). CARDIA has several features that permit us to test the limitations of the earlier study. The data include a) a sample with a broad range of income (range = $2500–$100,000; median = $66,544); b) a community-based sample subject to considerably less selection bias than the earlier study; c) sampling to provide large numbers of both men and women, and Blacks and Whites, thus increasing the power to examine potential moderating effects of gender and race; and d) a measure of occupational status in addition to measures of education and income used in the earlier study. Finally, like the earlier study, CARDIA includes a range of potential mediating variables including psychosocial factors and health practices that might account for associations of SES with catecholamines.

A previously published paper from CARDIA reported that another stress hormone, namely, cortisol, decreased with increasing SES (12). Thus, in addition to replicating and extending the results of the earlier SES and catecholamines study (11), the present report addresses whether the link between SES and physiologic stress is reliable across biological systems.

## METHODS

### Subjects

In 1985 to 1986, 5115 Black and White men and women, aged 18 to 30 years, were recruited to participate in CARDIA at four sites. The data reported here are based on a substudy conducted at follow-up year 15 at the Chicago, Illinois and Oakland, California sites. Details on sample recruitment and exclusion criteria were published previously (13,14). Participants were examined at study entry and years 2, 5, 7, 10, and 15. Institutional Review Board approval at the various sites and informed consent were obtained. The CARDIA Steering Committee approved this manuscript.

Of 1851 subjects who were seen at the Chicago and Oakland sites, 1336 persons met the substudy eligibility criterion of living within 50 miles of either site; 836 of those eligible agreed to participate. Of these, 730 provided a 12-hour urine sample. We excluded 44 participants with undetectable E, 13 participants who failed to provide SES data (income, occupation, education), and one participant who identified with a racial category other than Black or White. The final analysis was based on the remaining 672 participants, who represented 36.3% of participants seen at Oakland and Chicago. Participants included in the present sample were more likely to be Black ($\chi^2 = 15.57$; $p < .001$), less educated ($t = 3.06$; $p < .01$), and have a higher body mass ($t = 4.38$; $p < .001$) than the remaining 1179 participants who were seen at the above two sites but were not included in the present analyses.

### Catecholamines

E and NE were obtained from a 12-hour, overnight urine collection that took place in the participants' homes. During the year 15 CARDIA clinic visit, participants were given a 3-liter urine collection bottle that contained 1 g of sodium metabisulfite, a urinal (for men) or specimen hat (for women), a urine log book with instructions (that were reviewed with the participant before leaving the clinic), and a "reminder" card to be placed on the toilet they most likely would use during the collection period. Participants were instructed to collect all voids beginning 11 hours before their anticipated wake-up time and ending 1 hour after their anticipated wake-up time, and to record in their log books the actual start and end times of the collection period. Participants also were instructed to record any difficulties they encountered (e.g., missed or spilled specimens) and any medications they had taken during the 24 hours preceding their "anticipated stop time."

Aliquots to be assayed for NE and E were acidified to a pH of ≤3 and frozen at −80°C until assayed. Samples were analyzed by high-performance liquid chromatography with electrochemical detection (15) and creatinine by the method of Baranowski and Westenfelder (16). The sensitivity of the assay was 1.0 ng/ml. The intra- and interassay coefficients of variation (CVs) for E were 4.8% and 7.1%, respectively; intra- and interassay CVs for NE were 3.0% and 4.1%, respectively. NE and E values were adjusted by dividing respective concentrations (picomol NE or E per liter urine) by the creatinine concentration (micrograms of creatinine per liter of urine), and $\log_{10}$-transformed to normalize the distributions.

### Socioeconomic Status (SES)

We used four measures of SES: education, household income, occupational status, and a composite SES score that was derived from education, income, and status.

#### *Education*

Education was measured by highest grade (or year) of regular school completed. Participants were asked to select one code from 01 to 20, with 01 indicating the first year of elementary school and 20 indicating ≥4 years of graduate education.

#### *Income*

Household income was divided into nine categories, ranging from "less than $5,000" to "$100,000 or more." For analytic purposes, income was recoded to the midpoint of each of the nine categories ($100,000 for the highest category), and then cube-root transformed to reduce skewness.

#### *Socioeconomic Index (SEI)*

We used the Stevens and Cho SEI (17) as our measure of occupational status. SEI scores are a revision of the Duncan SEI (18), which was based on 1950 census data. The present SEI scores are "predicted prestige ratings" derived from a regression of the estimated proportion of people rating the prestige of an occupation as "good" or "excellent" based on a) the proportion of people in that occupation in 1970 with at least some college education and b) the proportion whose previous year's personal income was ≥$10,000 (19). These SEI scores, originally constructed for 1970 census occupational codes, were used subsequently to construct SEI scores for 1980 census codes (17). For the present study, status scores derived from the Stevens and Cho SEI were applied to the census codes associated with the participants' current occupations according to the year 15 sociodemographic interview.

#### *Composite SES*

A composite SES score was created by standardizing income, education, and occupational status (Z scores) and adding the standard scores.

### Potential Mediating Pathways

#### *Psychosocial Factors*

Psychosocial factors were assessed by questionnaire at the year 15 examination and included assessments of social support and integration, depressive symptoms, discrimination, personal mastery, and chronic stress. Social support from family and friends was assessed with an 8-item questionnaire (12). The first four items assessed how much friends and family members care for and provide support to the respondent, and the remaining four items assessed how often friends and family members criticize and make demands on the respondent. All responses were rated on a 4-point scale (1 = not at all; 4 = a lot). An emotional support score was computed from taking the average of the first four items and a demands/criticism (negative support) score was computed from taking the average of the last four items. The diversity of the participants' social networks was assessed by asking the participants to report on the number of close friends and close family members, as well as whether they belonged to one or more groups (e.g., social group, church group, labor union) (12). A social network diversity score was computed as the sum of three dichotomous measures: any close friends, any close relatives, and any group memberships. Depressive symptoms were measured using the Center for Epidemiologic Studies Depression scale (20), a 20-item instrument on which participants used a 4-point scale (0 = rarely or none of the time to 3 = most or all of the time) to indicate how often they experienced given symptoms during the preceding week. Experienced frequency of discrimination (based on gender, race, and SES) was assessed by asking the participants to indicate whether (yes, no) and how often (1 = rarely; 2 = sometimes; 3 =

often; 0 if participants answered "no" to whether they ever experienced discrimination) they experienced discrimination in seven situational or physical settings (at school, getting a job, getting housing, at work, at home, getting medical attention, on the street or in a public setting). Total discrimination scores in each domain were calculated by summing across the responses in each of the seven situational/physical settings (21). A sense of personal control and mastery was measured with Pearlin and Schooler's Self-Mastery Scale (22), a 7-item questionnaire on which the participants used a 5-point scale (1 = strongly agree to 5 = strongly disagree) to report the extent to which they feel that they possess personal mastery over life circumstances and outcomes. Chronic stress was assessed with the Chronic Burden Questionnaire (23). Participants indicated whether (yes, no) they had been experiencing ongoing problems (lasting ≥6 months) in the domains of work, finances, relationships, personal health and health of close others, and to what extent the ongoing problems were stressful (1 = no problem; 2 = yes, but not very stressful; 3 = yes, moderately stressful; 4 = yes, very stressful). For the purposes of the present study, the average chronic burden score was calculated by taking the average of scores from the domains of work, finances, relationships, and health of close others.

***Health Practices***

During each of the six CARDIA examinations, body mass index (BMI) (kg/m$^2$) was computed from the participants' height and weight measurements, and self-reported health practices were obtained by interview. Self-report measures included smoking status (current smoker = 1; former or never smoker = 0); drinker status (yes = 1; no = 0); alcohol consumption (total number of drinks consumed per week; one drink = one 12-oz. glass, bottle or can of beer, one 5-oz. glass of wine, or one 1.5-oz. shot of liquor); sleep duration (hours per night); sleep quality (1 = very good; 2 = fairly good; 3 = good; 4 = fairly bad; 5 = very bad); and physical activity (documented on CARDIA Web site) (24). Physical activity scores were computed by multiplying the participants' reported frequencies of engagement in 13 categories of exercise and recreational sport activity by the intensity of the activity (expressed in exercise units). Separate scores were derived for heavy intensity, moderate intensity, and total activity. Additional details on the scoring procedure are available elsewhere (25).

## Statistical Analyses

Table 1 displays the mean and standard deviation values of all measures. Correlations among SES measures are presented in Table 2.

We used multiple regression to estimate and test the association of continuous SES variables with urinary catecholamines. As age (years) and race (0 = White; 1 = Black) each were correlated with all SES measures (age: $r$ =.11–.17, $p <$ .01; race: $r$ = .30–.43, $p <$ .001) and being female was associated with lower income ($r$ = −.11, $p <$ .01), these variables were included as covariates in all analyses. All predictor and covariables were entered simultaneously as a single block. Separate models were used to examine each measure of SES as a predictor of catecholamine levels.

# RESULTS

## SES and Catecholamines

Table 3 displays regression coefficients for each of the four SES measures as predictors of urinary catecholamines. As expected, higher composite SES was associated with lower E. Separate income, education, and occupational status measures showed similar, albeit smaller associations with E. Continuous associations of SES with urinary NE paralleled those reported for E, in that higher composite SES scores were associated with lower NE, as were income, education, and occupational status. We explored the possibility of a curvilinear trend by including a quadratic term into each model. Results, however, indicated no significant quadratic effect (data not shown). Adjusted means for E and NE by level of SES are presented in Figures 1 and 2, respectively. Although analyses were based on continuous data, for the purposes of illustration, Figures 1 and 2 display the effects by quartile of SES.

Because earlier examinations of SES and markers of psychophysiologic stress in the CARDIA sample included only income and education as markers of SES (12), we computed a second composite SES variable that summed only the income and education z scores. Results from analyses incorporating this two-part composite measure were similar to those that used a composite that was comprised of the sum of income, education, and occupational status z scores (E: $b$ =

**TABLE 1. Sample Size, Mean, and Standard Deviation Values for Study Variables**

| Variable | *n* | Mean | SD |
|---|---|---|---|
| Urinary catecholamines | | | |
| Epinephrine, pmol/mg creatinine | 672 | 24.33 | 34.67 |
| Norepinephrine, pmol/mg creatinine | 672 | 203.15 | 120.87 |
| Controls | | | |
| Gender | 672 | 42% | |
| Race | 672 | 55% | |
| Age | 672 | 40.02 | 3.58 |
| SES | | | |
| Years of education | 672 | 14.91 | 2.42 |
| Income ($1000) | 672 | 65.18 | 29.67 |
| SEI score | 672 | 45.23 | 18.51 |
| Health practices | | | |
| BMI (kg/m$^2$) | 670 | 29.47 | 7.48 |
| Past smokers | 672 | 18% | |
| Current smokers | 672 | 17% | |
| Any alcoholic beverage in past year | 672 | 82% | |
| Milliliters of alcohol consumed/day | 672 | 3.82 | 8.36 |
| Physical exertion, moderate | 671 | 138.19 | 108.69 |
| Physical exertion, heavy | 671 | 219.37 | 226.58 |
| Physical exertion, total | 671 | 357.56 | 292.92 |
| Sleep quality rating | 672 | 2.52 | 0.99 |
| Average hours of sleep (past month) | 671 | 7.37 | 13.73 |
| Psychosocial measures | | | |
| CES-D depression score | 662 | 9.20 | 7.80 |
| Gender discrimination | 672 | 1.60 | 0.49 |
| Race discrimination | 671 | 1.55 | 0.50 |
| SES discrimination | 670 | 1.37 | 0.48 |
| Personal control/mastery | 672 | 28.84 | 4.34 |
| Social network diversity | 672 | 2.68 | 0.52 |
| Emotional support | 672 | 3.48 | 0.59 |
| Demands/criticisms | 672 | 2.12 | 0.65 |
| Chronic burden | 672 | 1.80 | 0.67 |

SD = standard deviation; SEI = socioeconomic index; BMI = body mass index; CES-D = Center for epidemiologic Studies-Depression scale; SES = socioeconomic status.

**TABLE 2. Univariate Pearson Correlations Within Predictor Variables**

| | 1. | 2. | 3. | 4. |
|---|---|---|---|---|
| 1. Education | — | 0.41* | 0.55* | 0.83* |
| 2. Income | | — | 0.34* | 0.73* |
| 3. Occupational status | | | — | 0.80* |
| 4. Composite SES | | | | — |

SES = socioeconomic status.
* $p <$ .001.

**TABLE 3. Regression Coefficients of SES Variables and Covariates Predicting Urinary Epinephrine and Norepinephrine[a]**

| Predictor | Epinephrine | | | | Norepinephrine | | | |
|---|---|---|---|---|---|---|---|---|
| | $R^2$ | *b* | *t* | *p* | $R^2$ | *b* | *t* | *p* |
| Covariates | .001 | | | | .07 | | | |
| Age | | −0.002 | −0.47 | <.64 | | 0.004 | 1.39 | <.17 |
| Race | | −0.006 | −0.22 | <.83 | | 0.02 | 1.20 | <.23 |
| Gender | | −0.01 | −0.48 | <.46 | | 0.13 | 7.03 | <.001 |
| Model 1 | .004 | | | | .08 | | | |
| Education | | −0.01 | −1.66 | <.097 | | −0.01 | −2.89 | <.01 |
| Model 2 | .007 | | | | .09 | | | |
| Income | | −0.004 | −2.09 | <.04 | | −0.004 | −3.07 | <.01 |
| Model 3 | .009 | | | | .08 | | | |
| SEI score | | −0.002 | −2.36 | <.02 | | −0.001 | −2.54 | <.02 |
| Model 4 | .01 | | | | .09 | | | |
| Composite SES | | −0.02 | −2.61 | <.01 | | −0.02 | −3.70 | <.001 |

Model 1 = covariates + education; Model 2 = covariates + income; Model 3 = covariates + occupational status; SEI = socioeconomic index; Model 4 = covariates + composite SES score; SES = socioeconomic status.

[a] All models controlled for age, race, and gender.

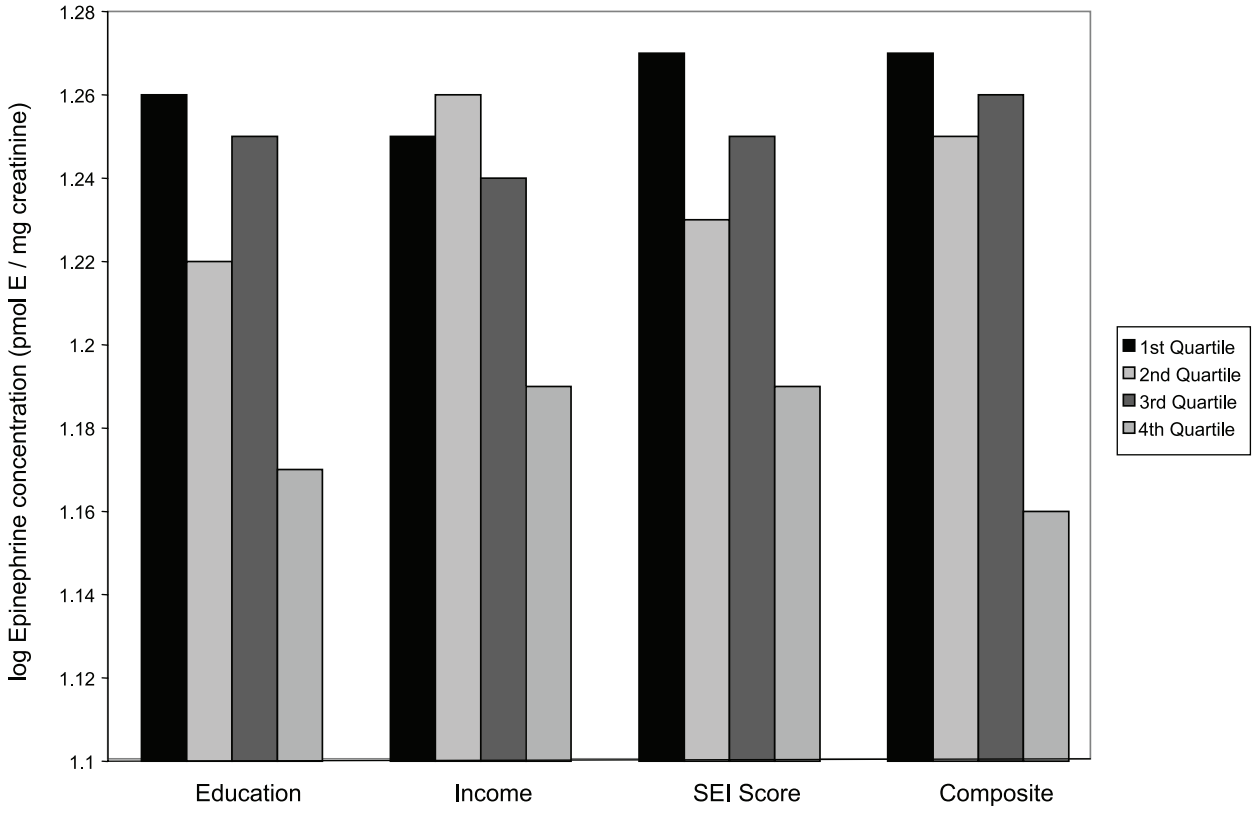


Figure 1. Urinary epinephrine by quartile of SES: adjusted means controlling for age, race, and gender. E = epinephrine; SEI = socioeconomic index.

$-0.02$, $t = -2.17$, $p < .05$; NE: $b = -0.02$, $t = -3.59$, $p < .001$).

### Potential Mediators

To determine whether psychosocial factors and/or health behaviors mediate the association of SES with urinary catecholamines, we first examined the correlation of each potential mediator with E and NE, respectively. Correlates of E were depression symptoms ($r = .08$, $p < .04$), BMI ($r = -.14$, $p < .001$), current smoker status (yes/no, $r = .15$, $p < .001$), moderate physical activity ($r = .10$, $p < .02$), and total physical activity ($r = .08$, $p < .05$). Correlates of NE were depression symptoms ($r = .09$, $p < .03$), demands/criticisms ($r = .14$, $p < .001$), chronic burden ($r = .09$, $p < .03$), current smoker status ($r = .09$, $p < .03$), heavy physical activity ($r = -.09$, $p < .02$), and total physical activity ($r = -.09$, $p < .02$).

After identifying correlates of E and NE, we estimated the percent reduction in associations between SES variables and

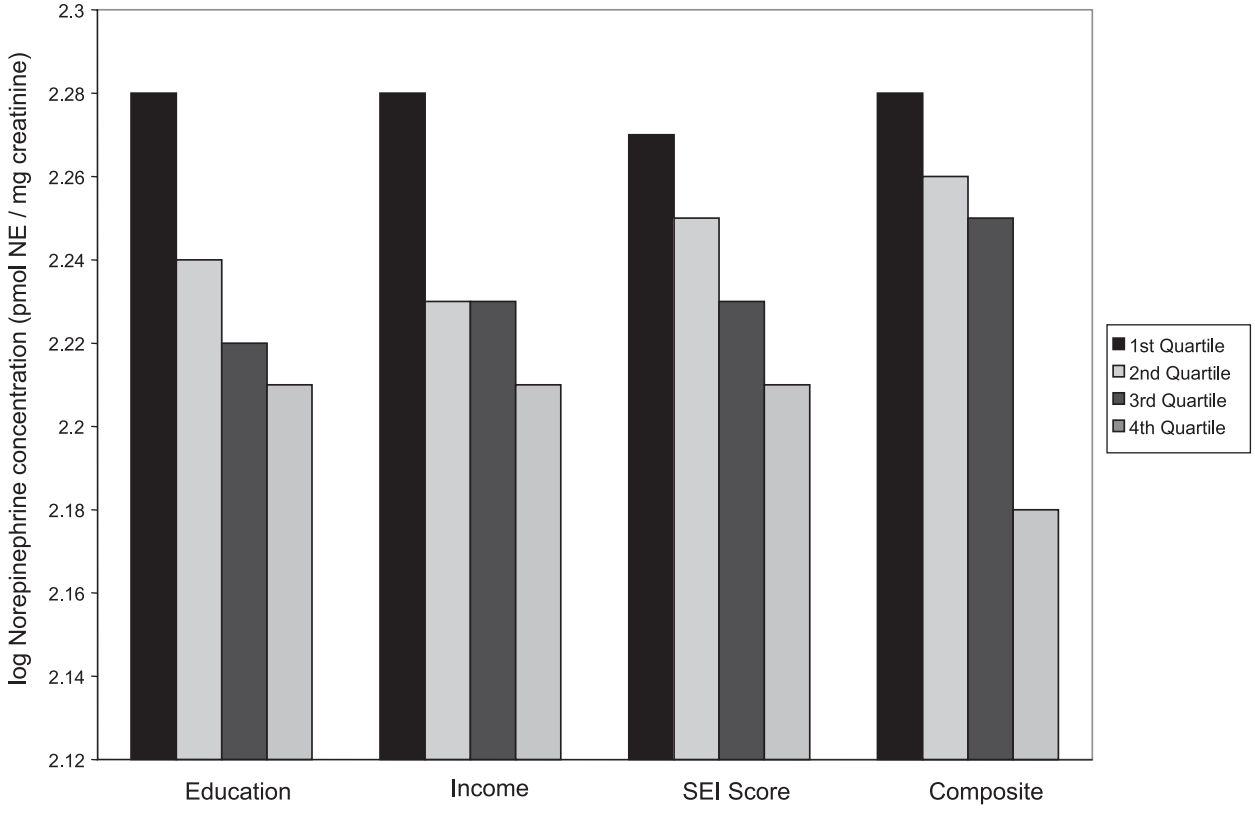


Figure 2. Urinary norepinephrine by quartile of SES: Adjusted means controlling for age, race, and gender. NE = norepinephrine; SEI = socioeconomic index.

**TABLE 4. Change in Regression Coefficients Predicting Urinary Epinephrine From SES Markers After Inclusion of Potential Mediators[a]**

| Predictor | *n* | *b* | SE | $p <$ | %Δ |
|---|---|---|---|---|---|
| Composite SES alone | 672 | −0.0154 | 0.0059 | 0.01 | — |
| +BMI | 669 | −0.0177 | 0.0058 | 0.01 | +15% |
| +Current smoking status | 672 | −0.0103 | 0.0061 | 0.09 | −33% |
| +Moderate activity | 671 | −0.0155 | 0.0059 | 0.01 | 0 |
| +Total activity | 671 | −0.0153 | 0.0059 | 0.01 | −0.06% |
| +Depression | 662 | −0.0126 | 0.0061 | 0.05 | −18% |
| +Smoking status and depression | 662 | −0.0088 | 0.0062 | 0.16 | −43% |

SES = socioeconomic status; SE = standard error; BMI = body mass index.
[a] Each potential mediator examined in a separate model and all models include control for age, race, and gender.

each catecholamine (unstandardized betas) when we controlled for potential mediators in addition to age, race, and gender (12). We used separate models to examine each potential mediator. Results for composite SES scores are presented in Tables 4 and 5 for E and NE, respectively. As shown in Table 4, depressive symptoms and smoking status each accounted for a substantial reduction in the effect of composite SES on E, with more depressive symptoms and smoker status each predicting higher E. Interestingly, adjustments for BMI increased the association of SES and E.

Potential mediators played a comparatively smaller role in associations of SES with NE. As shown in Table 5, smoking status accounted for the greatest percent reduction in the association of composite SES score with NE. Other contributing factors included depression, demands/criticisms, and chronic burden.

### Moderation by Gender and Race

Because we were interested in whether the association of SES with catecholamines may differ as a function of gender or race, we examined gender and race as moderators. Gender moderated the inverse association of income with NE (gender-by-income interaction: $b = 0.005$, $t = 2.03$, $p < .05$), such that the effect was stronger for men than for women (men: $b = -0.007$, $p < .001$; women: $b = -0.002$, $p < .27$; difference: $b = 0.005$, $p < .05$). No other moderating effects were significant.

## DISCUSSION

Regardless of whether measured in terms of income, education, or occupation, higher SES was associated with lower urinary catecholamine levels, independent of age, race, and gender. These findings are in agreement with those reported in

**TABLE 5. Change in Regression Coefficients Predicting Urinary Norepinephrine From SES Markers After Inclusion of Potential Mediators[a]**

| Predictor | *n* | *b* | SE | *p* | %Δ |
|---|---|---|---|---|---|
| Composite SES alone | 672 | −0.0157 | 0.0043 | <.001 | — |
| +Current smoking status | 672 | −0.0138 | 0.0044 | <.01 | −12% |
| +Heavy activity | 671 | −0.0157 | 0.0043 | <.001 | 0 |
| +Total activity | 671 | −0.0157 | 0.0043 | <.001 | 0 |
| +Depression | 662 | −0.0142 | 0.0044 | <.01 | −10% |
| +Demands/criticisms | 672 | −0.0144 | 0.0043 | <.001 | −8% |
| +Chronic burden | 672 | −0.0151 | 0.0043 | <.001 | −4% |
| +Depression, chronic burden, demands/criticisms | 662 | −0.0138 | 0.0044 | <.01 | −12% |
| +Smoking status and depression | 662 | −0.0130 | 0.0045 | <.01 | −17% |
| +Smoking, depression, chronic burden, demands/criticisms | 672 | −0.0128 | 0.0045 | <.01 | −18% |

SES = socioeconomic status; SE = standard error.
[a] Each potential mediator examined in a separate model and all models include control for age, race, and gender.

previous U.S. studies (5,11), but contrast with those reported in the Taiwanese study, which found no effect of SES on catecholamine levels (10). These apparent cross-cultural differences in the association of SES and catecholamines may be due to between-group differences in how SES is defined. Additionally, differences in age between the U.S. and Taiwanese samples may have accounted for the differing results. The Taiwanese sample was comprised entirely of elderly (≥71 years) and "near elderly" persons (54–70 years). It is possible that lower SES may have a less pronounced effect on the catecholamine levels of older adults than it does on those of comparatively younger adults and children. Future research will be necessary to determine the extent to which older age and culture, independently or in combination, contribute to these differing effects.

The present results extend the findings reported by Cohen et al. (11) in three important ways. First, given the difference in average SES between the present sample and the sample used in the earlier study (median income = $66,544 versus $20,000), our results suggest that the association of SES with catecholamines persists across the income gradient. Second, the present multiple community-based sample is less biased than that used in the previous study (11) in regard to self-selection. Thus, we can infer that the results reported here are more generalizable to that of the larger U.S. population. Finally, the present study found that lower occupational status—in addition to lower income and lower education—is associated with higher levels of urinary catecholamines. This finding suggests that the association of SES with catecholamine levels is robust, regardless of how SES is operationalized.

When examined by quartile, the inverse associations of all four SES measures with E appear to be driven largely by a protective effect at the highest quartile (Figure 1), whereas only the association of NE with the composite SES score suggests a threshold effect of this kind (Figure 2). However, given the lack of significant quadratic effects, it is reasonable to conclude that the linear trends reported in Table 3 provide the best description of the data examined here.

Our mediation analyses suggest that associations of SES with catecholamines can be accounted for, in part, by depressive symptoms and smoking status. These two factors explained almost half (43%) of the association of composite SES with E. Depression and smoking also contributed to the associations of composite SES with NE, but to a lesser extent. As indicated by Table 5, however, the combined contribution of depressive symptoms and smoking was considerably greater than the combined contribution of depression and chronic burden (17% versus 12%, respectively). Further, the proportion of the association between SES and NE accounted for by depression and smoking was not increased substantially with the addition of chronic burden (18%). These findings are consistent with those reported for the low-income sample (11), where smoking accounted for 19% to 21% of the association of SES with catecholamines above and beyond the effects of age, race, gender, and BMI, and depression accounted for 5.5% to 9.2% of the association independent of age, race, gender, and BMI.

Interestingly, gender moderated the association of income with NE, such that the relationship was stronger for men. It is possible that household income is more closely tied to physiologic sequelae in men than in women. Among married couples, husbands often contribute more to household income than do wives. Because of the comparatively greater monetary investment on the part of husbands, the level of household income may be more personally relevant to husbands than to wives, and thus more likely to influence physiologic activity. Alternatively, because equity of job opportunity is independent of income distribution, with women often making less than men in similar jobs, women may invest themselves more in other components of SES (e.g., education), and thus be less affected by differences in income (26).

Although significant, the inverse association between lower SES and higher catecholamine levels is not large. It is possible that the choice of 12-hour overnight urine collection, rather than 24-hour collection, for measurements of E and NE might have influenced our findings. By excluding measurement of catecholamines during the first half of the day, we have failed to capture physiologic activity during those hours. However, it has been shown that overnight catecholamine measures correlate well with 24-hour measures (27).

In sum, the results reported here further support the hypothesis that lower SES is accompanied by increased physi-

ologic distress (1). Moreover, the association of low SES with increased urinary catecholamines is consistent across Blacks and Whites, and across measures of SES. Strengths of the present study include a large sample of both genders and a substantial percentage of minority persons (55% Black). Limitations include the cross-sectional design and the fact that only Blacks and Whites were represented. Additional research conducted on samples that include a broader range of minority groups is necessary to determine if the present results are generalizable to the U.S. population at large. The present findings suggest that the associations of SES with morbidity and mortality, like the association of SES with health outcomes, is apparent at higher as well as lower ranges of SES. As exaggerated activity of the SNS, indicated by chronic increases in circulating catecholamines, has been implicated in the pathogenesis of various diseases (3), the present findings also suggest a potential pathway involving elevated SNS activity to explain the graded association between SES and physical morbidity and mortality. Future prospective research might more directly explore this possibility by examining whether elevated catecholamine levels mediate the association between low SES and increased risk of future clinical disease.

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