Is the Association between Socioeconomic Position and Coronary Heart Disease Stronger in Women than in Men?

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The association between socioeconomic position and health is generally believed to be weaker among women than men. However, gender differences in the relation between socioeconomic position and coronary heart disease have not been evaluated in a representative sample of the US population. The authors examined this association in the First National Health and Nutrition Examination Survey (1971–1993), a longitudinal, representative study of the US population (n = 6,913). Information on educational attainment, household income, and covariates was derived from the baseline interview, and that on incident coronary heart disease was obtained from hospital records/death certificates over 22 years of follow-up. Cox’s proportional hazards models showed that education and income were inversely associated with incident coronary heart disease in age-only and multivariate models. Risk associated with education varied by gender (p = 0.01), with less than high school education associated with stronger risk of coronary heart disease in women (relative risk = 2.15, 95% confidence interval: 1.46, 3.17) than in men (relative risk = 1.58, 95% confidence interval: 1.18, 2.12) in age-adjusted models. Low education was associated with greater social and psychological risks for women than men; however, metabolic risks largely explained gender differences in the educational gradient in coronary heart disease.

coronary disease; education; heart diseases; income; poverty; sex; socioeconomic factors

Abbreviations: CI, confidence interval; ICD-9, International Classification of Diseases, Ninth Revision; NHANES I, First National Health and Nutrition Examination Survey; RR, relative risk.

The socioeconomic gradient in health is well described, with poorer health associated with lower socioeconomic position. This gradient is particularly evident for coronary heart disease (1–3). The socioeconomic gradient in coronary heart disease persists across virtually the entire socioeconomic spectrum, with additional reductions in risk observed at even the highest levels of socioeconomic position (1–3). However, less is known about how the socioeconomic gradient in incident coronary heart disease may differ between men and women.

The socioeconomic gradient in health is traditionally believed to be weaker for women than for men (4–6), attributed in part to issues of measurement of socioeconomic position among women (7, 8). However, gender differences in associations between socioeconomic position and health depend upon a variety of factors, including age of participants (6); marital status (4); choice of socioeconomic indicator (6, 9–11), including whether a woman is classified by personal, partner, or household socioeconomic position (9, 10, 12); inclusion of women outside the paid workforce (9); and health outcomes examined. While outcomes such as total mortality exhibit weaker (4, 11, 13, 14) or comparable (5, 11) socioeconomic gradients for women relative to men, several studies suggest that socioeconomic gradients in coronary heart disease may be stronger in women (1). Although not entirely consistent (15–17), studies of subclinical atherosclerosis (18, 19), incident coronary heart disease (20), and coronary heart disease mortality (4, 10, 14, 21, 22) in European samples and of coronary heart disease mortality in US samples (3) suggest stronger associations among women. However, little of this work has been designed explicitly to consider gender.
differences in the association between socioeconomic position and coronary heart disease.

Important questions regarding gender differences in the socioeconomic gradient in coronary heart disease remain. Few studies have been able to examine gender differences in the association between socioeconomic position and incident coronary heart disease prospectively. Many investigations fail to include both women and men, and those including both genders generally do not perform statistical tests of gender differences. Even fewer have evaluated these associations in nationally representative samples. Moreover, little is known about factors accounting for any observed gender differences. Key social and psychological experiences (6, 23–26) and behavioral and biomedical factors associated with low socioeconomic position, coronary heart disease risk, and/or gender that may account for observed gender differences. We paid particular attention to potential differential clustering of social and psychological risks by gender. Risks included single parenting, unemployment, high depressive symptoms, and the co-occurrence of both low income and low education, selected on the basis of prior research (24–26), relevance to coronary heart disease (1, 29, 30), and data availability. Hypotheses were evaluated using data from the First National Health and Nutrition Examination Survey (NHANES I) and NHANES I epidemiologic follow-up surveys (1982–1992), together comprising a nationally representative, population-based study. We hypothesized that 1) lower socioeconomic position would be associated with greater risk of incident coronary heart disease, and 2) the association between socioeconomic position and incident coronary heart disease would be stronger in women than in men. In an exploratory fashion, we examined social and psychological factors (high depressive symptoms, single parenting, unemployment, multiple indicators of low socioeconomic position), behavioral factors (smoking, alcohol use, physical activity), and biomedical factors (hypertension, systolic and diastolic blood pressure, diabetes, body mass index, cholesterol) that might account for gender differences in coronary heart disease risk associated with socioeconomic position.

MATERIALS AND METHODS

Sample and study design

Study participants are respondents to NHANES I, a multistage, national probability survey conducted between 1971 and 1974 in the US civilian noninstitutionalized population aged 1–74 years. The study oversampled women of childbearing age, persons living in poverty areas, and elderly persons. The baseline assessment, including medical examination, blood draw, and in-person structured interview, was conducted on the full cohort. A detailed medical examination and selected psychological measures were obtained on a representative subsample of noninstitutionalized adults aged 25–74 years (n = 6,913) (31), comprising the sample for the present investigation. Of those contacted for participation, the interview nonresponse rate was 1.4 percent, and the physical examination nonresponse rate was 30.5 percent. Interview nonresponders did not differ from participants on any demographic characteristics. However, older age, lower education, and residence in large urban centers were associated with examination nonresponse. Details of the study design and sampling procedures are published elsewhere (32).

Follow-up studies were conducted in 1982, 1987, and 1992 on the entire surviving NHANES I cohort aged 25–74 years at the baseline examination (33–35) and additionally in 1986 on those participants aged 55–74 years at baseline (36). Assessments included in-person interviews or automated telephone interviews with the respondent or proxy (for decedents), blood pressure and weight measurements, tracking of all members via the National Death Index, and obtaining of death certificates and records of reported hospital and nursing home stays.

This study included members of the detailed subsample (n = 6,913), all of whom were traced at one or more follow-ups. Of these participants, 453 were excluded from the analysis because of baseline evidence of cardiovascular disease by self-report or physical examination, and an additional 435 were excluded because of missing values for one or more variables. The final sample available for analysis included 6,025 participants (2,750 men, 3,275 women). Participants missing one or more variables were more likely to be an ethnic minority (p = 0.008), unemployed (p < 0.001), unmarried (p = 0.01), sedentary (p = 0.002), a nondrinker (p = 0.02), and a person with high levels of depressive symptoms (p < 0.001).

Socioeconomic position

Education and household income were considered indicators of socioeconomic position. The level of educational attainment, total combined household income, and family size were derived from the NHANES I interview. Combined household income was the only income measure available in the NHANES I interview. Education was categorized into less than high school, high school graduate, some college, and college graduate or higher. Household income was categorized as under 100 percent, 100–200 percent, and over 200 percent of 1973 (median year of the NHANES I examination) poverty thresholds based upon reported family size.

Other psychosocial measures

Additional social and psychological factors considered included single parenting, employment status, and depressive symptoms. Participants were classified as a single parent if they reported being unmarried, being the head of household, and living with one or more related individuals. Participants who reported working for the past 3 months were classified as employed. Those that reported keeping house were classified as homemakers. Among participants reporting doing “something else,” those who specified...
being laid off, looking for work, or staying home were classified as unemployed, and those who specified being retired, unable to work, a student, ill, or “other” were classified as “other.” Depressive symptoms were measured using the cheerful versus depressed mood subscale of the General Well Being Schedule, a validated measure with known psychometric properties (37). Scores (possible range: 0–25) were grouped into three levels, using cutpoints adopted and validated by previous investigators (38–41): scale scores of 0–12 considered high, 13–18 considered moderate, and 19–25 considered low levels of symptoms. A psychosocial risk score was calculated on the basis of the number of risks present for each individual (household income under poverty, unemployment, single parenting, high depressive symptoms), where each factor contributed a one-point increase to the score (range: 0–4).

**Incident coronary heart disease**

Coronary heart disease events were identified by hospital/nursing home discharge reports and death certificates. At each follow-up, participants reported all hospital or nursing home stays since the last study contact. Hospitals/nursing homes were then contacted with participant permission, and discharge reports were obtained for all visits in the study period. Participants were also tracked via the National Death Index, and death certificates were obtained for decedents. A coronary heart disease event was coded if the International Classification of Diseases, Ninth Revision (ICD-9), codes 410–414 were listed on the hospital/nursing home discharge report or as the cause of death on the death certificate. The date of nonfatal coronary heart disease events was coded as the discharge date, and if no discharge date was available, the event date was the admission date. The date of a fatal coronary heart disease event was the date of death on the death certificate. For participants with more than one event (e.g., myocardial infarction followed by coronary heart disease death), only the first event was considered, and the participant was thereafter censored. Results restricting coronary heart disease events to ICD-9 codes 410, 411, and 414 were also considered. Since results were largely unchanged, results utilizing ICD-9 codes 410–414 are presented here.

**Covariates**

Information on gender, smoking status (current, never/former), leisure time physical activity (sedentary-light, moderate, regular exercise), and alcohol use (none, ≤2, >2 servings/day) was obtained from responses to the NHANES I interview. Hypertension or diabetes status was determined from the NHANES I interview-reported past or present physician diagnosis and/or the past or present medication use for the condition. Age and race/ethnicity (White, non-White) reported in the NHANES I interview were updated/corrected in 1982 to resolve discrepancies between interviews (33), with corrected values used in the present analyses. Systolic and diastolic blood pressure values were obtained from one seated measurement taken during the NHANES I physical examination. Body mass index (weight (kg)/height (m)\(^2\)) was calculated from the NHANES I physical examination.

**Statistical analyses**

Gender differences in baseline demographic, medical, and psychological characteristics were evaluated using t tests and chi-squared tests. Follow-up time was calculated from the date of the baseline interview to the date of a coronary heart disease event, non-coronary heart disease death, or date last known alive. Relative risks of incident coronary heart disease and 95 percent confidence intervals associated with education and household income were each estimated separately in multivariate Cox’s proportional hazards regression (SAS Proc PHREG; SAS Institute, Inc., Cary, North Carolina) to account for unequal follow-up time. Each model was estimated with adjustment for age and subsequently for the covariates race/ethnicity, unemployment, single parenting, depressive symptoms, smoking status, aerobic exercise, alcohol use, systolic blood pressure, diastolic blood pressure, body mass index, cholesterol, hypertension, and diabetes status. Effect modification of socioeconomic position on coronary heart disease by gender was examined and reported where significant. Results were also stratified by gender.

The number of additional social and psychological risks (household income under poverty, unemployment, single parenting, high depressive symptoms) was calculated for each individual as a psychosocial risk score. Because of the highly skewed distribution of risks, gender differences in the relation between low education and the psychosocial risk score were evaluated via Poisson regression, including the main effects gender, education, and a gender-by-education interaction term. A dispersion parameter estimated by use of Pearson’s chi square was included in the specification of the variance given evidence of underdispersion.

The impact of covariates on the interaction between socioeconomic position and gender on coronary heart disease risk was estimated by adjustment for blocks of covariates (with the exception of the psychosocial risk score): 1) age and race; 2) psychosocial risk score; 3) health behaviors (aerobic exercise, smoking, alcohol use); 4) cardiovascular factors (hypertension, systolic and diastolic blood pressure); and 5) metabolic factors (diabetes, cholesterol, body mass index). The impact of any one social, psychosocial, behavioral, or biologic risk factor alone in age- and race-adjusted models was subsequently evaluated. The mediational effect of any variable or blocks of variables on gender differences in the impact of education on coronary heart disease was estimated in age-adjusted models as 1 – log(hazard ratio adjusted)/ log(hazard ratio unadjusted) (42), and changes in the education-by-gender interaction term from the prior model were assessed. Differential associations between education and body mass index by gender were estimated within multiple linear regression with adjustment for age and race, including the main effects and education-by-gender interaction term. Models were also stratified by gender.

Analyses were conducted using SAS, version 8.2, software (SAS Institute, Inc.). All tests are two sided at \( p = 0.05 \). Models were subsequently estimated to account...
for the complex survey design, incorporating sample weights, clustering, and stratification within the SAS-callable version of SUDAAN, version 9.0, software (Research Triangle Institute, Research Triangle Park, North Carolina). Because findings were largely unchanged, results unadjusted for the complex survey design are presented here.

RESULTS

Over the follow-up period of a mean of 15.1 (standard deviation: 5.9) years, death certificates or hospital/nursing home records indicated 609 incident coronary heart disease events (237 fatal, 372 nonfatal) among men and 487 incident coronary heart disease events (161 fatal, 326 nonfatal) among women. Baseline demographic, health, social, and psychological characteristics by gender are presented in table 1. Notably, men had a significantly increased risk of a coronary heart disease event relative to women in age-only models (relative risk (RR) = 1.73, 95 percent confidence interval (CI): 1.53, 1.94) and in models adjusted for demographic, socioeconomic, psychological, behavioral, and biomedical factors (RR = 1.97, 95 percent CI: 1.63, 2.39).

Socioeconomic position and incident coronary heart disease

When men and women were considered together in age-adjusted Cox proportional hazards models, education and household income were both separately and inversely associated with incident coronary heart disease. Relative to a college education or higher, less than high school (RR = 1.73, 95 percent CI: 1.37, 2.17) and a high school education (RR = 1.30, 95 percent CI: 1.02, 1.66) were associated with significantly increased coronary heart disease risk, and some college (RR = 1.32, 95 percent CI: 0.99, 1.76) was associated with marginally increased risk. Household income under the poverty threshold (RR = 1.42, 95 percent CI: 1.21, 1.66) and from one to two times the poverty threshold (RR = 1.17, 95 percent CI: 1.01, 1.34) was associated with significantly increased coronary heart disease risk relative to household income over two times the poverty threshold. In models adjusting for known cardiovascular risk factors, less than a high school education (RR = 1.40, 95 percent CI: 1.10, 1.77) or income under the poverty threshold (RR = 1.37, 95 percent CI: 1.16, 1.62) was associated with significantly increased risk relative to college education or income over two times the poverty threshold, respectively.

Socioeconomic position and incident coronary heart disease: gender differences

The increased coronary heart disease risk associated with low education and low income appeared stronger in women relative to men (table 2). Formal tests of this difference were conducted, and, for education, the interaction term describing this gender difference was significant ($p = 0.01$) in age-adjusted models. The interaction term between gender and income did not reach significance ($p = 0.19$).

We conducted a series of analyses examining potential explanatory factors for the gender difference in the education and incident coronary heart disease association. We considered the extent to which social and psychological risks, including income under the poverty threshold, high depressive symptoms, unemployment, and single parenting, “traveled with” low education. We noted that the number of social and psychological risks associated with less than a high school education varied significantly by gender ($p = 0.0004$) and that women with a low level of education had more additional social and psychological risks than did men with a low level of education in age-adjusted models. Among women with less than a high school education, 13.5 percent had two or more and 46.6 percent had one or more additional risks. Corresponding percentages among men were 5.6 and 29.8.

In age- and race-adjusted models, adjustment for the number of social and psychological risks accounted for some (13 percent), but not all, of the interaction between education and gender on coronary heart disease risk, and the interaction term remained significant ($p = 0.02$). Further adjustment for health behaviors, including smoking, alcohol use, and aerobic exercise, left the interaction term unchanged. Additional adjustment for hypertension status and systolic and diastolic blood pressure attenuated some of the effect (an additional 16 percent) but failed to eliminate the gender difference, and the interaction term remained significant ($p = 0.04$). Finally, adjustment for cholesterol, diabetes status, and body mass index rendered the interaction between education and gender nonsignificant ($p = 0.42$), together accounting for 59 percent of the gender difference in the association between education and coronary heart disease. When each social, psychosocial, behavioral, and biomedical variable was subsequently examined alone in age- and race-adjusted models, body mass index accounted for the largest portion of the interaction between gender and education on coronary heart disease risk. Body mass index was the only single factor to render the interaction between education and gender nonsignificant ($p = 0.11$), alone accounting for 37 percent of the gender difference in the association between education and coronary heart disease risk.

To further understand these relations, we considered gender differences in the association between education and baseline body mass index. Linear regression analyses suggested that the educational gradient in body mass index was stronger among women than men (interaction between education and gender: $p < 0.001$) in age- and race-adjusted models. Specifically, relative to a college education, less than a high school education ($\beta = 2.44$; $p < 0.001$) and a high school education ($\beta = 1.43$; $p < 0.001$) were strongly and positively associated with body mass index among women. Among men, a high school education was significantly ($\beta = 0.76$; $p = 0.002$) and some college was marginally ($\beta = 0.55$; $p = 0.06$) associated with higher body mass index, relative to a college education (figure 1). Thus, women with less than a high school education and a high school education had a 2.44- and a 1.43-kg/m$^2$ higher body mass index, respectively, than did college-educated women. In contrast, men with a high school education and with some
college education had a 0.76- and 0.55-kg/m² higher body mass index, respectively, than did college-educated men.

**DISCUSSION**

This study demonstrated that lower education and income were associated with increased coronary heart disease risk in a nationally representative, population-based study. Results were generally robust to adjustment for multiple biomedical and behavioral covariates. This study also indicated that coronary heart disease risk associated with low education was stronger among women than among men. Women with low levels of education had more concurrent social and psychological risks than did men. However, a large portion
of the gender difference in the education-coronary heart disease gradient was accounted for by metabolic risk factors, including body mass index, which showed a stronger educational gradient among women.

This study is notable for several reasons. First, to our knowledge, it is the first to compare gender differences in incident coronary heart disease risk associated with socioeconomic position in a nationally representative sample. Second, this study showed that a low level of education was associated with more psychosocial disadvantage for women, suggesting a synergistic effect of stratifying the characteristics of class and gender (43). Finally, this study is the first to explicitly consider factors accounting for this gender disparity, indicating the importance of metabolic factors.

### TABLE 2. Cox’s proportional hazards models of socioeconomic position and incident coronary heart disease, by gender, First National Health and Nutrition Examination Survey, United States, 1971–1993*

<table>
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<tr>
<th></th>
<th>Coronary heart disease risk</th>
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<tbody>
<tr>
<td></td>
<td>Adjusted for age</td>
<td>Adjusted for age and covariates†</td>
<td>Adjusted for age</td>
<td>Adjusted for age and covariates†</td>
<td></td>
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<tr>
<td></td>
<td>Relative risk</td>
<td>95% confidence interval</td>
<td>Relative risk</td>
<td>95% confidence interval</td>
<td>Relative risk</td>
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<tr>
<td>Education</td>
<td></td>
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<tr>
<td>Less than high school</td>
<td>1.58</td>
<td>1.18, 2.12</td>
<td>1.29</td>
<td>0.96, 1.74</td>
<td>2.15</td>
</tr>
<tr>
<td>High school</td>
<td>1.42</td>
<td>1.04, 1.92</td>
<td>1.17</td>
<td>0.86, 1.59</td>
<td>1.47</td>
</tr>
<tr>
<td>Some college</td>
<td>1.43</td>
<td>1.00, 2.04</td>
<td>1.31</td>
<td>0.91, 1.87</td>
<td>1.35</td>
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<tr>
<td>College Referent</td>
<td>Referent</td>
<td>Referent</td>
<td>Referent</td>
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<tr>
<td>Annual household income relative to poverty threshold‡</td>
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<td></td>
<td></td>
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<tr>
<td>&lt;100%</td>
<td>1.40</td>
<td>1.11, 1.76</td>
<td>1.35</td>
<td>1.06, 1.71</td>
<td>1.64</td>
</tr>
<tr>
<td>100–200%</td>
<td>1.20</td>
<td>0.99, 1.46</td>
<td>1.15</td>
<td>0.95, 1.40</td>
<td>1.23</td>
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<tr>
<td>&gt;200%</td>
<td>Referent</td>
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* Education and income considered in separate models.
† Covariates: systolic and diastolic blood pressure, hypertension status, cholesterol, body mass index, diabetes status, smoking, alcohol use, aerobic exercise, marital status, and race/ethnicity.
‡ Total annual household income, categorized by 1973 poverty thresholds for family size.

The socioeconomic gradient in health has historically been assumed to be weaker among women relative to men, assumptions largely derived from studies of total mortality (4–6). However, in the case of cardiovascular disease, previous work has suggested a stronger gradient among women (4, 10, 14, 18, 19, 21, 22), although rarely have explicit tests of these gender differences been performed. Findings in the present study are congruent with this previous work, providing the strongest evidence to date of a steeper education gradient in incident coronary heart disease among women relative to men.

Although both total family income and education were inversely associated with the risk of incident coronary heart disease, only in the case of education was a significant gender difference observed in this study. As opposed to income, education is acquired relatively early in life, is generally stable throughout life, and may therefore reflect socioeconomic conditions beginning early (44) and extending throughout life (8). In fact, evidence indicates the importance of early life socioeconomic conditions on metabolic risks, an association particularly robust for women (45, 46). In addition, education indicates personal educational level, whereas household income, the only income indicator available in this study, blends income from all sources in a household. Thus, education, particularly in this study, may more accurately reflect a woman’s own socioeconomic position. Finally, education is not sensitive to workforce participation. Therefore, associations between education and health may be observed among women, who have less consistent workforce participation (8).

Our findings indicate that the educational gradient in body mass index, in combination with other metabolic risks, may account for a large portion of the steeper educational gradients in coronary heart disease among women. The stronger association between socioeconomic position and body mass index (27, 47, 48) and other metabolic risks (28, 49) among women has been indicated previously, and metabolic risks such as diabetes confer greater coronary heart disease risk for women (45). Despite these observations, to our knowledge, this study is the first to explore metabolic pathways as an explanation of gender differences in the socioeconomic gradient in coronary heart disease.

Pathways linking socioeconomic position and body mass index are likely multiple, including increased total energy and fat consumption (50), decreased leisure time physical activity (51–53) and resources to support these behaviors (54, 55), or stress-related neuroendocrine dysfunction (56, 57). However, they do not explain the gender differences in socioeconomic gradients in relation to body mass index. Social pressure for thinness is stronger among females than males, particularly among high-socioeconomic-position women (27), with associated dieting behavior (50). A stronger socioeconomic gradient in smoking among men (1, 14), associated with a lower body mass index (58), may contribute to inconsistent associations between socioeconomic position and body mass index among men (27) but would not explain weaker educational gradients in coronary heart disease among men. Finally, associations between socioeconomic position and body mass index are likely bidirectional, particularly for women. Obesity is associated with greater social stigma and discrimination for women than men (27) and may have a particularly deleterious impact on women’s socioeconomic attainment (27, 59).

Women with a low level of education were more likely than men to have a low income, to be unemployed, to have high depressive symptoms, and to be single parents. Thus, women with a low level of education may experience more psychosocial disadvantage than men (24–26). This clustering may reflect the synergistic effects of class and gender, two stratifying characteristics that may confer greater disadvantage than each alone (43). Although this clustering of psychosocial risks accounted for a small portion of the gender differences in the education-coronary heart disease association, the risks available were very limited. This study may have inadequately captured key social risks disproportionately impacting women with a low socioeconomic position, including intimate partner violence (60), discrimination (24), and other deleterious household processes (61).

Our findings should be interpreted in light of several limitations. Incident coronary heart disease was based upon discharge reports and death certificates and may have been misclassified. Diagnoses on discharge reports or death certificates also may have been inaccurate, increasing error in coronary heart disease measurement and downwardly biasing estimates. Discharge reports and death certificates would not have included silent, or unrecognized, myocardial infarction, more common among women (62). Given later disease manifestation among women (63), more women than men in this study did not reach an age at which coronary heart disease clinically manifests. Thus, coronary heart disease events among women may have been underestimated. Given the nonresponse rates, elderly, less educated, and urban-dwelling individuals may not be as well represented in this study. Finally, although the socioeconomic indicators were measured prior to incident disease measures, they were measured at the same point as were the risk factor measures. The causal nature and direction of any observed associations cannot be assumed. This study has several key methodological strengths. It is a large, longitudinal, nationally representative study of the US population, including large numbers of women and men. It allowed examination of incident coronary heart disease, established by hospital/nursing home records and death certificates as opposed to self-report, and baseline disease status determined by physical examination.

This study indicates that coronary heart disease, a disease impacted by metabolic processes, may show stronger educational gradients among women relative to men. This study points to socioeconomic position as a crucial women’s health issue, with gender and class intersecting with potentially important psychosocial and cardiovascular impact.

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