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Does Self-Rated Health Mean the Same Thing Across Socioeconomic Groups? Evidence From Biomarker Data

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Abstract

Purpose—Self-rated health (SRH) is widely used to study health inequalities by socioeconomic status (SES), but concern has arisen that SRH may not correspond to objective health in the same way for different SES groups. We test whether levels of biological risk differ by SES for those with the same SRH.

Methods—We analyzed a U.S. nationally representative sample of 13,877 adults aged 25 to 80 years. We tested whether education modifies the association between SRH and 14 biomarkers representing metabolic, cardiovascular, inflammatory, and organ function using both interaction models and models stratified by four levels of SRH. Estimated education coefficients in the stratified models indicated whether biomarker levels varied by educational attainment within a given self-rated health category.

Results—Significant variation in biological risk by education within the same self-rated health category was found, especially at higher levels of SRH. In general, respondents with more education had healthier levels of biomarkers for the same level of SRH.

Conclusions—The results suggest that the relation of self-reported health to objective health, as measured by biological risk factors, differs by socioeconomic status. Caution should be exercised when using SRH to compare health risks across SES groups.

Keywords

Biomarkers; Education; NHANES; Self-Rated Health; Socioeconomic Status

Introduction

Self-rated health (SRH) status on a five-point scale has been used extensively in the study of health inequalities by socio-economic status (SES), based partly on its ease of collection and consistent associations with subsequent morbidity and mortality (1–3). Concerns have arisen, however, that the measurement of health inequalities with SRH may be biased if individuals from different socioeconomic groups have systematically different expectations

or reporting standards for health, sometimes called “reporting heterogeneity” (4, 5). Recently, other investigators have examined whether equivalent SRH translates into the same “objective” health status across different socioeconomic groups by testing whether the association of SRH with mortality risk varies by SES. Results have been mixed; SRH was a stronger predictor of mortality for higher SES groups in the United States and the Netherlands, a weaker predictor for higher SES groups in France, and an equal predictor across SES in Sweden and the United Kingdom (6–12). Several investigators also have found evidence for reporting heterogeneity by SES by using alternative benchmarks for “objective” health such as self-reported clinical illnesses or physical functioning (13, 14), or the more detailed self-reported MacMaster Health Utility Index and SF-36 instrument (4, 15).

Profiles of biological risk present a promising “objective” benchmark for SRH with several advantages over mortality risk or other self-reported measures such as functional limitations or chronic conditions. The use of self-reported conditions or functional limitations as a benchmark for SRH cannot rule out reporting heterogeneity that may be shared by both sets of self-reports. The use of clinical or physician-reported illness as a benchmark also suffers from potential biases resulting from differential access to care and probability of diagnoses. Biomarkers, in contrast, are measured in the laboratory and avoid this type of systematic reporting error. Although a few researchers have investigated the relation of biomarkers to SRH (16–18), only one study to our knowledge has tested whether levels of biomarkers across SRH categories vary by SES. In the United Kingdom, average measures of body mass index (BMI) and blood pressure across two categories of SRH were found to differ between manual versus nonmanual worker categories for women but not for men (19).

We aimed to expand upon this work by analyzing a broader array of biomarkers and a wider range of SRH and SES categories in a large, nationally representative U.S. sample. We tested whether levels of important markers of metabolic, cardiovascular, and inflammatory risk and organ functioning vary by education for adults reporting the same category of SRH. These results will contribute evidence to the nature of reporting differences in SRH and improve our understanding of the strengths and potential biases of SRH as a measure of population health.

Methods

Data are from the Third National Health and Nutrition Examination Survey (NHANES III), conducted by the U.S. National Center for Health Statistics between 1988 and 1994. NHANES III is a cross-sectional stratified multistage probability sample of the civilian noninstitutionalized U.S. population age 2 months to 90 years. Data were collected in household interviews, clinical examinations, and laboratory tests. Details of the sampling design and protocol have been previously reported (20, 21).

We defined the analysis sample as adults 25 to 80 years of age with valid education and SRH information and at least one valid biomarker value. The NHANES III dataset included 15,346 persons ages 25 to 80. In this age group, 1378 adults (8.98%) did not participate in the medical examination where blood for biomarker analysis was collected. Among those

who underwent examination, 86 adults (0.62%) were missing education, and another 5 respondents (0.04%) were missing SRH. Missing values for individual biomarkers ranged from 37 cases (0.27%) for BMI to 1020 cases (7.35%) for lung function markers. Fibrinogen was only assessed for adults 40 years and older and was available for 59.3% of the analysis sample ($n = 8224$). The final sample included 13,877 respondents. Being older, white, and from the Northeast were associated with a greater likelihood of not participating in the medical examination. Controlling for these factors, sex, education, and SRH were not associated with likelihood of participating in the examination.

Measures

Self-Rated Health—SRH was determined by the question, “Would you say your health in general is excellent, very good, good, fair, or poor?” Because of the small proportion of respondents reporting poor health (Table 1), we collapsed fair and poor into one category for analysis, for a total of four categories.

Biological Indicators—We analyzed 14 biological risk factors, including traditional markers of cardiovascular risk: systolic blood pressure (BP; mm Hg), diastolic BP (mm Hg), total cholesterol (mg/dL), and high-density lipoprotein (HDL) cholesterol (mg/dL). Measures of metabolic functioning included waist-to-hip ratio, BMI, and glycated hemoglobin (%; HbA1c, an integrated measure of glucose metabolism over the previous 30–90 days). Markers of inflammation included C-reactive protein (CRP; mg/L), serum albumin (g/dL), fibrinogen (mg/dL), and white blood cell count. Three markers of organ system function included peak expiratory flow (PEV) and forced vital capacity (FVC) for lung function and glomerular filtration rate (GFR) for kidney function, calculated from serum creatinine by use of the Cockcroft-Gault equation (22). For the majority of markers, greater levels represent greater levels of risk; the exceptions are HDL cholesterol, albumin, PEV, FVC, and GFR, for which greater levels are associated with lower disease risk. All biomarkers were modeled as continuous variables, with the exception of CRP, which was coded as 1 if >3 mg/L and 0 otherwise, because of a significant percentage of values below the detection limit.

Education—We used education as a marker of SES. Compared with income, education is a more stable marker of lifetime SES and less likely than income to be subject to reverse causality from poor health to lower SES. We also estimated all models with income as the SES indicator, with comparable results (available upon request). Education was included continuously as the number of completed years of schooling.

Statistical Analysis

Analyses were conducted separately for men and women and adjusted for continuous age. We estimated 3 types of models. First, we calculated the mean value of each biomarker for the full sample, as well for each of the four levels of SRH. We used design-adjusted Wald tests to assess differences in biomarker values across the four levels of SRH to test whether biomarker values were related to health ratings.

Next, we estimated ordinary least squares regressions for each biomarker separately, including terms for continuous SRH, continuous education, and their interaction. These models tested whether education significantly modified the association between SRH and each biomarker.

Although the interaction models can tell us whether the distance between excellent and poor health in terms of cholesterol levels, for instance, varies by education, they cannot tell us whether absolute levels of cholesterol within each SRH category differ by education (which reflects both main and interaction effects). To answer that question, we stratified the sample by SRH levels and estimated linear regression models for the association of education with each biomarker. These models tested whether, at a given health rating, adults with different educational attainment have different biomarker values. A significant coefficient for education indicates different levels of biological risk within the same health category by education; conversely a null finding for education indicates comparable biological risk across education levels within a given SRH level. All analyses used NHANES III final examination weights, and standard errors were calculated with Taylor-linearized variance estimation, available in Stata 10.1 (23).

Results

Descriptive statistics for the sample are shown in Table 1. A total of 21% of respondents reported “excellent” health, 30.4% “very good,” 32.3% “good,” 13.0% “fair,” and 3.3% “poor.” Mean levels of biomarkers across four categories of SRH are shown separately in Table 2 for men and women. For almost all markers, mean levels differed significantly across SRH categories in the expected direction. Those reporting worse health had greater levels of systolic and diastolic BP, BMI, waist-hip ratio, total cholesterol (for women), fibrinogen, HbA1c, white blood cell count, and CRP. They had, on average, lower levels of HDL cholesterol, serum albumin, GFR, PEV, and FVC. These findings confirm a systematic association between the biomarkers and global ratings of SRH.

Table 3 shows that the main effects of education and SRH are in the expected direction, whereby respondents with more education and better SRH have more favorable biomarker levels. The significant interaction effects indicate that the relative association between SRH and each biomarker is modified by education for all biomarkers except total cholesterol and HbA1c. The interaction coefficients are consistent in direction; the association between SRH and each biomarker is stronger at greater levels of education. Because age might be an additional modifier of the association between SRH, education, and biomarkers, we also tested for the three-way interaction between age, education, and SRH for each biomarker, finding little evidence of effect modification by age (results available upon request).

Having identified a significant SRH*education interaction, we next tested whether these translated into different absolute levels of biomarkers once both main effects and interaction effects were taken into account. Table 4 shows coefficients for the association of years of education on each biomarker, stratified by level of SRH. In the absence of absolute reporting differences, the education coefficient within each level of SRH should be zero. For both men and women, we could reject the null hypothesis of no reporting differences by education

more than one-half of the time (35/56 coefficients for men, 30/56 for women). The differences were more pronounced in better health categories and somewhat less pronounced in the “poor/fair” health category. For example, for men reporting “excellent” health, those with more education had significantly healthier levels of systolic BP, BMI, waist-hip ratio, HDL cholesterol, fibrinogen, HbA1c, albumin, FVC, white blood cell count, and CRP. The effect sizes were substantively significant: among men reporting “excellent” health, each additional year of education was associated with a .70 point reduction in systolic BP, a .40 point increase in HDL cholesterol, and a 1.1% lower probability of CRP >3 mg/L. There were fewer significant associations in the “poor/fair” health category, suggesting that for individuals reporting poor/fair health, those with different levels of education have comparable levels of biological risk.

Nevertheless, the measures of BMI, PEV, FVC, and leukocyte count still showed differences by education for men reporting “poor/fair” health. With a few exceptions, the direction of the education coefficient suggested that for each SRH category, men with more education were better off with respect to the measured biomarkers. Interestingly, the pattern for BMI in men showed that although at the highest health levels more educated men had lower levels of BMI, the education effect diminished across the health scale until those reporting “poor/fair” health with more education had greater levels of BMI.

The patterns were similar for women: more educated women generally had healthier biomarker profiles within each category of SRH, with more significant differences in education for the greater health categories compared with lower health categories. Among women reporting “excellent” health, those with more education had significantly healthier levels of systolic BP, BMI, waist-hip ratio, total cholesterol, HDL cholesterol, fibrinogen, PEV, FVC, white blood cell count, and CRP.

Discussion

Using data from a nationally representative U.S. sample, we identified differences in biological risk within SRH categories by education, especially for higher levels of SRH. These results provide evidence that a given level of SRH may not translate into the same objective health for different SES groups and suggest that researchers should use caution in interpreting differences in SRH by SES.

Strengths of this study include the use of a large, nationally representative sample of the noninstitutionalized U.S. population, a detailed measure of educational attainment, and a wide array of biological markers to capture disease risk. To our knowledge, only one previous study examined differences in biological risk by SES within categories of SRH (19). By using data from the 1998 Health Survey of England, Adams and White found that women but not men who were manual workers had greater systolic BP and BMI than non-manual working women who reported their health as “good” or “very good.” These results for women are consistent with our findings of a stronger socioeconomic variation within higher categories of SRH, which we found for both women and men. Our current work here substantially expands upon this work, wherein we examined 14 compared with 2 biomarkers

of risk and used the full range of educational attainment and SRH categories, compared with the dichotomized SRH and SES variables in Adams and White (19).

Our findings are consistent with previous findings that SRH is more strongly associated with mortality in the U.S. for higher SES individuals (7). One potential explanation for this phenomenon in the context of our findings is that more educated individuals may have better knowledge of their underlying biological risk, both through knowledge of disease determinants and more interaction with health care providers. If adults with less education are less aware of their risks, they may rate their health greater than is warranted. This explanation would suggest that the educational differences would be more likely for biomarkers such as BP or cholesterol, which may be reported by physicians to patients during examinations, than for biomarkers such as HbA1c or GFR that are unlikely to be known by the respondent. We find, however, no evidence for this pattern. In contrast, there are strong educational differences within SRH category by BMI, waist-hip ratio, and lung function, indicators of health about which all respondents are at least generally aware and could incorporate into their health assessment. Although educational groups might differ in their assessment of health risk associated with increased body size, a functional measure such as peak flow should be less susceptible to this type of bias. Furthermore, we also see educational differences for markers such as fibrinogen, GFR, and CRP that are not regularly tested by physicians. These results suggest that the worse profiles of biological risk among those reporting higher levels of health with less education are not merely due to differential knowledge of underlying biological risks.

Besides differential knowledge of objective health status, SES differences in SRH reporting may be the result of systematic differences in the use of the ordinal response scale. Individuals may understand and use the ordinal response scale in different ways, such as the propensity to use extreme categories, or general optimism or pessimism. If one group has consistently lower standards for what is considered “excellent” health for instance, they will report systematically better health than other groups. For example, individuals with less education may compare themselves to their relatively less healthy peers, leading report better health than is warranted (24). A uniform shift in thresholds used to define response categories is referred to as a “parallel cut-point shift,” whereas any change in the relative positions of reporting thresholds such as the distances between categories is referred to as a “non-parallel cut-point shift” (25).

Our results shed light on whether differences in reporting SRH by SES are a result of a parallel or nonparallel cut-point shifts. A parallel shift would have been consistent with coefficients on education of roughly the same magnitude and direction for all SRH categories in our biomarker regressions. In contrast, we see much stronger educational differences in the greater health categories, whereas the coefficients are closer to zero and sometimes changing signs in the lower health categories. These patterns, combined with the significant results of the interaction models, strongly suggest nonparallel cut-point shifts in the SRH scale, whereby the distances between health categories (as represented by biomarkers) are different by SES. With these markers, we have strong evidence that the underlying health scale is compressed for individuals with less education, with a smaller absolute distance (measured by biological risk) between the excellent and poor categories.

This pattern could reflect a ceiling effect, whereby the healthiest and most educated respondents lack a higher reporting category despite having healthier biological profiles than less educated persons reporting excellent health.

It has been widely recognized that SRH is a broadly inclusive measure, encompassing not only current health status, but also elements of health behaviors, psychological and social well-being, and trajectories in health over time (26–29). In a recent commentary, Huisman and Deeg (29) suggest that SRH should be recognized as a measure of people's perception of their health rather than a proxy for objective health, which is difficult to measure. This may be good general advice, but in practice researchers typically use SRH to measure health inequalities on the basis of its established association with morbidity and mortality rather than as a measure of health perception. This implies that measuring and explaining differences in objective health are the typical goals when modelling inequalities in SRH. For such research, it is thus important to identify any discrepancies in the correspondence of SRH to objective health by SES. Our analysis implicitly focuses on SRH as a proxy for disease risk that can be represented by an array of biomarkers. Our findings are most important for researchers who use SRH status as an easy and inexpensive way to compare long-term morbidity and mortality risk across SES groups. Our analysis cannot speak to any specific components of SRH, such as psychological and social well-being, that are not reflected in biological risk. Furthermore, to the extent that the included biomarkers do not correspond to differences in current functioning and/or future disease risk, we cannot definitively conclude that SRH does not correspond to “objective” health in the same way for different groups. Nevertheless, a strength of our approach is that the included biomarkers cover a broad array of the key clinical and nonclinical risk factors for cardiovascular disease, diabetes, and kidney disease and lung function. In addition, our analyses assumes that equivalent levels of each biomarker correspond to the similar risk of morbidity and mortality across social groups; to the extent that having multiple biomarkers in the high-risk range is socially patterned and contributes to more than additive risk, the interpretation of our results may differ.

Overall, we found substantial evidence of differences in the biological risk associated with SRH categories by SES. In the majority of cases, these differences corresponded to better health for those with more education in greater health categories, which would lead to an *underestimation* of health inequalities on the basis of this measure. Taken together with similar results for of SES difference in the association of SRH and mortality (6–12), this work suggests that researchers should use caution when using SRH to investigate the magnitude and causes of health inequalities by SES.

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Selected Abbreviations and Acronyms

SRH	self-rated health
SES	socioeconomic status
BMI	body mass index
NHANES	National Health and Nutrition Examination Survey
BP	blood pressure
HDL	high-density lipoprotein
HbA1c	glycated haemoglobin
CRP	C-reactive protein
PEV	peak expiratory flow
FVC	forced vital capacity
GFR	glomerular filtration rate

Table 1
Descriptive statistics, by gender (NHANES III, 1988–1994)

	All	Men	Women
Age, mean, (SD)	46.2 (15.0)	45.5 (14.7)	46.9 (15.2)
Female	51.5%	–	–
Race, %			
White	77.1	77.5	76.7
Black	10.7	10.0	11.4
Mexican-American	4.7	5.0	4.4
Other	7.5	7.5	7.5
Education, %			
>HS education	24.5	25.2	23.9
HS education	33.7	30.5	36.7
<HS education	42.8	44.4	39.4
Self-rated health, %			
Excellent	21.0	22.2	20.0
Very good	30.4	31.3	29.4
Good	32.3	32.1	32.5
Fair	13.0	11.5	14.4
Poor	3.3	2.9	3.7
n	13,938	6,524	7,414

Weighted sample statistics.

HS = high school; NHANES = National Health and Nutrition Examination Survey.

Table 2

Mean biomarker levels by self-rated health category

Biomarker	Men						Women					
	Self-rated health						Self-rated health					
	Total	Excellent	Very good	Good	Fair/ poor	p-value	Total	Excellent	Very good	Good	Fair/ poor	p-value
Systolic BP	125.15 (17.6)	121.56	124.01	126.94	129.37	<.001	120.59 (20.7)	114.74	118.77	121.92	127.86	<.001
Diastolic BP	77.54 (10.3)	76.47	77.65	78.21	77.46	<.001	72.74 (10.1)	70.83	72.36	73.55	74.07	<.001
Body mass index	26.90 (4.9)	25.77	26.75	27.56	27.54	<.001	26.79 (6.6)	24.77	25.89	27.64	28.98	<.001
Waist-hip ratio	0.96 (.07)	0.94	0.96	0.97	0.99	<.001	0.87 (.08)	0.84	0.86	0.88	0.91	<.001
Total cholesterol	205.77 (42.1)	202.64	205.29	207.04	208.96	.017	208.73 (46.0)	200.90	206.12	209.21	220.78	<.001
HDL cholesterol	45.59 (14.8)	47.73	45.68	44.35	44.82	<.001	55.23 (16.1)	58.72	56.13	54.30	51.52	<.001
Fibrinogen	297.38 (89.7)	281.99	285.50	300.96	325.79	<.001	309.34 (87.8)	286.48	302.00	311.72	332.36	<.001
HbA1c %	5.43 (1.1)	5.29	5.33	5.52	5.72	<.001	5.38 (1.2)	5.08	5.22	5.42	5.89	<.001
GFR	95.03 (29.3)	93.65	97.16	97.16	87.53	<.001	82.00 (30.6)	80.90	80.89	84.72	80.07	<.001
Peak expiratory flow	9024.8 (2328.0)	9572.8	9409.7	8792.7	7758.9	<.001	6079.0 (1634.2)	6714.8	6438.9	6009.8	5403.3	<.001
Forced vital capacity	4794.0 (979.2)	5016.5	4979.1	4682.3	4253.0	<.001	3330.2 (744.4)	3576.2	3493.6	3246.2	2907.7	<.001
White blood cell count	7.27 (2.3)	6.69	7.18	7.62	7.61	<.001	7.22 (2.4)	6.83	7.12	7.32	7.64	<.001
CRP >3.0 mg/L, %	23.6	12.9	16.9	30.7	39.4	<.001	35.1	20.7	30.3	39.4	51.4	<.001

BP = blood pressure; CRP = C-reactive protein; GFR = glomerular filtration rate; HDL = high-density lipoprotein.

Table 3
Main and interaction effects for education and self-rated health

	Men			Women		
	Education	SRH	Education ^a SRH	Education	SRH	Education ^a SRH
Systolic BP	-0.729 ^c	0.794 ^c	0.189 ^c	-0.522 ^c	1.421 ^c	0.102 ^a
Diastolic BP	-0.176	0.329 ^a	0.105 ^c	-0.229	0.784 ^c	0.101 ^b
Body mass index	-0.334 ^c	0.485 ^c	0.121 ^c	-0.450 ^c	1.136 ^c	0.118 ^c
Waist-hip ratio	-0.004 ^c	0.010 ^c	0.001 ^c	-0.006 ^c	0.012 ^c	0.001 ^b
Total cholesterol	-0.156	0.424	0.122	-1.133 ^c	1.337 ^a	0.215
HDL cholesterol	0.416 ^b	-1.071 ^c	-0.192 ^c	0.964 ^c	-1.743 ^c	-0.123 ^a
Fibrinogen	-3.591 ^c	9.432 ^c	0.846 ^b	-2.676 ^b	11.487 ^c	0.698 ^a
HbA1c %	-0.032 ^c	0.063 ^c	0.003	-0.002	0.173 ^c	-0.006
GFR	-1.296 ^c	2.090 ^c	0.551 ^c	-1.226 ^c	3.324 ^c	0.413 ^c
Peak expiratory flow	105.163 ^c	-228.176 ^c	8.066	96.555 ^c	-190.056 ^c	-4.756
Forced vital capacity	41.583 ^c	-91.976 ^c	2.287	62.329 ^c	-91.879 ^c	-8.200 ^b
Leukocyte count	-0.185 ^c	0.235 ^c	0.045 ^c	-0.128 ^c	0.227 ^c	0.027 ^b
CRP > 3.0 mg/L	-0.028 ^c	0.067 ^c	0.008 ^c	-0.025 ^c	0.087 ^c	0.009 ^c

β coefficients from separate OLS regressions for each individual biomarker on age, years of education, SRH, and the interaction between education and SRH.

BP = blood pressure; CRP = C-reactive protein; GFR = glomerular filtration rate; HDL = high-density lipoprotein; OLS = ordinary least squares; SRH = self-rated health.

^a $p < .1$.

^b $p < .05$.

^c $p < .01$. Main and interaction effects come from jointly estimated models.

Table 4
Association of years of education with individual biomarkers, stratified by SRH categories

	Men				Women			
	Excellent	Very good	Good	Fair/Poor	Excellent	Very good	Good	Fair/poor
Systolic BP	-0.702 ^c	-0.148	-0.079	-0.173	-0.509 ^c	-0.272 ^b	-0.268	-0.016
Diastolic BP	-0.149	0.198 ^a	0.192 ^a	0.049	-0.072	0.074	0.048	0.130
Body mass index	-0.159 ^c	-0.118 ^b	0.058	0.123 ^a	-0.289 ^c	-0.228 ^c	-0.089	0.046
Waist-hip ratio	-0.002 ^b	-0.002 ^c	-0.001	-0.001	-0.004 ^c	-0.004 ^c	-0.004 ^c	-0.002 ^b
Total cholesterol	0.492	-0.701	0.965 ^b	-0.382	-1.494 ^c	-0.510	-0.224	-0.169
HDL cholesterol	0.403 ^b	-0.057	-0.390 ^b	-0.034	0.802 ^c	0.591 ^b	0.806 ^c	0.352 ^b
Fibrinogen	-2.927 ^b	-2.650 ^a	-1.494 ^a	1.323	-2.779 ^b	-1.240	-1.224	0.949
HbA1c %	-0.023 ^c	-0.036 ^c	-0.023 ^c	-0.015 ^a	-0.016	-0.029 ^b	-0.014	-0.015
GFR	-0.329	-0.529 ^a	0.629 ^c	0.654 ^b	-0.100	-0.654 ^b	-0.058	0.499 ^b
Peak expiratory flow	145.476 ^c	113.350 ^c	133.847 ^c	106.939 ^c	128.803 ^c	56.023 ^c	92.968 ^c	72.861 ^c
Forced vital capacity	52.789 ^c	48.827 ^c	47.835 ^c	36.979 ^c	64.603 ^c	39.960 ^c	45.745 ^c	14.664 ^b
Leukocyte count	-0.113 ^c	-0.086 ^c	-0.079 ^c	0.013	-0.084 ^c	-0.104 ^c	-0.048 ^a	0.009
CRP > 3.0mg/L	-0.015 ^c	-0.019 ^c	-0.002	0.011 ^b	-0.014 ^b	-0.011 ^a	-0.002	0.015 ^c

Note: β coefficients from separate OLS models for each biomarker and SRH category on years of education, controlling for age.

BP = blood pressure; CRP = C-reactive protein; GFR = glomerular filtration rate; HDL = high-density lipoprotein; OLS = ordinary least squares; SRH = self-rated health.

^a $p < .1$.

^b $p < .05$.

^c $p < .01$.