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Education, Income, and Incident Heart Failure in Post-Menopausal Women

The Women's Health Initiative Hormone Therapy Trials

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Objectives The purpose of this study is to estimate the effect of education and income on incident heart failure (HF) hospitalization among post-menopausal women.

Background Investigations of socioeconomic status have focused on outcomes after HF diagnosis, not associations with incident HF. We used data from the Women's Health Initiative Hormone Trials to examine the association between socioeconomic status levels and incident HF hospitalization.

Methods We included 26,160 healthy, post-menopausal women. Education and income were self-reported. Analysis of variance, chi-square tests, and proportional hazards models were used for statistical analysis, with adjustment for demographics, comorbid conditions, behavioral factors, and hormone and dietary modification assignments.

Results Women with household incomes <$20,000 a year had higher HF hospitalization incidence (57.3/10,000 person-years) than women with household incomes >$50,000 a year (16.7/10,000 person-years; $p < 0.01$). Women with less than a high school education had higher HF hospitalization incidence (51.2/10,000 person-years) than college graduates and above (25.5/10,000 person-years; $p < 0.01$). In multivariable analyses, women with the lowest income levels had 56% higher risk (hazard ratio: 1.56, 95% confidence interval: 1.19 to 2.04) than the highest income women; women with the least amount of education had 21% higher risk for incident HF hospitalization (hazard ratio: 1.21, 95% confidence interval: 0.90 to 1.62) than the most educated women.

Conclusions Lower income is associated with an increased incidence of HF hospitalization among healthy, post-menopausal women, whereas multivariable adjustment attenuated the association of education with incident HF. (J Am Coll Cardiol 2011;58:1457–64) © 2011 by the American College of Cardiology Foundation

Heart failure (HF) is a growing epidemic, but little is known about the association between HF incidence and socioeconomic status (SES) in the U.S. Prior investigations report that lower SES patients have increased morbidity and mortality after HF diagnosis (1), but data are sparse regarding an association between low SES and HF incidence. Less

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Abbreviations and Acronyms

CI = confidence interval

HF = heart failure

HR = hazard ratio

SES = socioeconomic status

educated and lower income persons have increased prevalence of cardiovascular disease risk factors (2), resulting in increased risk for ischemic heart disease and stroke (3,4). In European cohorts, lower SES patients also appear to have increased HF risk (5), but these studies are not representative of the U.S. population or its health care delivery system. The purpose of this study was to examine the association of income and education with incident HF.

Methods

We used data from the WHI (Women's Health Initiative) hormone trials (6), a series of randomized, controlled trials that tested the effects of hormone therapy on a variety of health outcomes among healthy, post-menopausal women. We excluded women with baseline HF (n = 198), cardiac arrest (n = 81), coronary artery bypass grafting (n = 509), percutaneous coronary intervention (n = 180), or missing information during follow-up (n = 268), yielding a cohort of 26,160 healthy post-menopausal women for this analysis.

Records were obtained and adjudicated every 6 months for self-reported HF hospitalizations, as well as possible HF events found during adjudication of other cardiovascular outcomes (e.g., myocardial infarction). Three cardiologists reviewed all records independently using the WHI and FHS (Framingham Heart Study) diagnostic criteria to identify HF cases (7). Ambulatory cases of HF were not included. The WHI criteria required a physician diagnosis of HF and medical treatment for HF during the index admission, with/without an imaging procedure showing impaired systolic or diastolic left ventricular function. The FHS criteria required a specific combination of major and minor criteria (7). Disagreements were resolved by consensus decision.

We identified 663 incident cases of HF: 294 met only the WHI criteria, 8 met only the FHS criteria, and 361 met both criteria. For the current analysis, we used all 663 incident HF cases a priori to maximize power and conducted sensitivity analyses on the 361 cases that met both WHI and FHS criteria. Results were similar when analyzing with WHI or FHS criteria separately.

Educational attainment was determined by self-report and collapsed into 3 categories from 5 categories collected by the WHI (Table 1). Similarly, annual household income was determined by self-report and collapsed into 4 categories (Table 2).

We used analysis of variance and chi-square tests to compare baseline characteristics according to SES. Cox proportional hazards models were used to evaluate the effect of SES on incident HF. In the multivariable regression, we adjusted for age, race/ethnicity, marriage status, hormone assignment, dietary modification assignment, level of physical activity, smoking status, alcohol consumption, body mass index, interim myocardial infarction (modeled as a time-varying covariate), systolic blood pressure, hypertension, diabetes mellitus, and health insurance. Ejection fraction was available from the index hospitalization for 78% of the women diagnosed with HF, but was unavailable for women without HF; therefore, it was not included in the statistical analyses. Ejection fraction measured during index hospitalization did not differ across education or income groups among women who had a first-time HF hospitalization (data presented in Online Tables 1 and 2).

In secondary analyses, we stratified our income models at age 66 years to account for possible differential income effects in employment and retirement age women. We also performed a stratified analysis between white women and black women to evaluate the role of race/ethnicity. The small number of HF events among Hispanics (n = 24) and Asians/Pacific Islanders (n = 8) prevented meaningful analysis of risk in these subgroups. In race/ethnicity-stratified analysis, we were unable to model interim myocardial infarction as a time-varying covariate because of the small number of events among black women. Analysis was performed using SAS version 9.2 (SAS Institute, Cary, North Carolina). We found no evidence for significant interaction between education and income levels for risk of incident HF. All p values < 0.05 were considered statistically significant.

Results

Among 26,160 participants, 7.7% (n = 2,013) had less than a high school education and 21.8% (n = 5,694) had household incomes of <$20,000/year. Several risk factors, including hypertension, diabetes, and interim myocardial infarction, were significantly more prevalent among lower SES women (Tables 1 and 2).

Incident HF hospitalization occurred at a higher rate among low-income women during the follow-up period; event rates decreased from 57.3 to 16.7 per 10,000 person-years between the lowest and highest income categories ($p < 0.01$) (Fig. 1A). In the unadjusted model, low-income women had a HF hospitalization hazard >3 times higher than high-income women (hazard ratio [HR]: 3.43, 95% confidence interval [CI]: 2.68 to 4.38) (Fig. 2A).

In the multivariable model, women from the lowest income group had a 56% significantly higher hazard of incident HF hospitalization compared to women from the highest income group. Women with incomes $20,000 to $34,999 annually had a 42% significantly higher hazard and women with $35,000 to $50,000 annually had a 20% insignificantly higher hazard of incident HF hospitalization compared to the highest income women (Fig. 2A).

The relationship between education and incident HF hospitalization followed a similar pattern to income—incidence

Table 1 Baseline Characteristics of Participants According to Education

Characteristics	Less Than High School (n = 2,013)	High School ± Some College/Vocational School (n = 15,985)	College Graduate ± Any Graduate Study (n = 8,027)
Sociodemographic variables			
Age, yrs	63.7 ± 7.1	63.4 ± 7.1	63.1 ± 7.4
Race/ethnicity			
White	1,051 (52.2)	13,188 (82.5)	6,827 (85.1)
Black	347 (17.2)	1,483 (9.3)	713 (8.9)
Hispanic	527 (26.2)	700 (4.4)	193 (2.4)
Asian/Pacific Islander	29 (1.4)	309 (1.9)	168 (2.1)
Other	47 (2.3)	274 (1.7)	110 (1.4)
Marriage status			
Never	45 (2.2)	333 (2.1)	604 (7.5)
Divorced	360 (17.9)	2,694 (16.9)	1,531 (19.1)
Widowed	470 (23.4)	3,364 (21.0)	1,297 (16.2)
Married	1,123 (55.8)	9,562 (59.8)	4,583 (57.1)
Insurance type			
No insurance	585 (29.1)	1,877 (11.8)	560 (7.0)
Medicare	329 (16.3)	1,460 (9.1)	588 (7.3)
Medicaid	63 (3.1)	86 (0.5)	10 (0.1)
Medicare + Medicaid	46 (2.3)	95 (0.6)	22 (0.3)
Private insurance	547 (27.2)	7,899 (49.4)	4,543 (56.6)
Private + Medicare	396 (19.7)	4,444 (27.8)	2,255 (28.1)
Behavioral/lifestyle variables			
Smoking status			
Never	1,063 (52.8)	7,856 (49.2)	4,071 (50.7)
Former smoker	650 (32.3)	6,188 (38.7)	3,222 (40.1)
Current	265 (13.2)	1,774 (11.1)	651 (8.1)
Alcohol use			
Nondrinker	489 (24.3)	1,931 (12.1)	739 (9.2)
Former drinker	615 (30.6)	3,312 (20.7)	1,107 (13.8)
0–7 drinks/week	800 (39.7)	9,002 (56.3)	4,903 (61.1)
7+ drinks/week	71 (3.5)	1,605 (10.0)	1,225 (15.3)
Physical activity			
No activity	525 (26.1)	3,040 (19.0)	1,061 (13.2)
Minimal activity	894 (44.4)	6,598 (41.3)	2,974 (37.1)
Moderate activity	157 (7.8)	2,144 (13.4)	1,357 (16.9)
Strenuous activity	237 (11.8)	2,843 (17.8)	1,976 (24.6)
Medical variables			
SBP ≥140 mm Hg, DBP ≥90 mm Hg, or treated HTN	898 (44.6)	6,570 (41.1)	2,705 (33.7)
Body mass index, kg/m^2	30.4 ± 6.1	29.3 ± 6.0	28.2 ± 5.8
Diabetes mellitus	215 (10.7)	1,013 (6.3)	326 (4.1)
MI during follow-up	49 (2.4)	258 (1.6)	83 (1.0)
HRT			
Intervention	1,033 (51.3)	8,104 (50.7)	4,005 (49.9)
Placebo	980 (48.7)	7,881 (49.3)	4,022 (50.1)
Dietary modification			
Not randomized	1,464 (72.7)	11,142 (69.7)	5,740 (71.5)
Intervention	211 (10.5)	1,870 (11.7)	971 (12.1)
Control	338 (16.8)	2,973 (18.6)	1,316 (16.4)

Values are mean ± SD or n (%). All p values for the comparison of characteristics according to education group are significant at a level of $p < 0.01$, with the exception of hormone replacement therapy ($p = 0.46$).

DBP = diastolic blood pressure; HRT = hormone replacement therapy; HTN = hypertension; MI = myocardial infarction; SBP = systolic blood pressure.

increased with lower levels of education ($p < 0.01$) (Fig. 1B). In the unadjusted model, women with less than a high school education had double the hazard for incident HF hospitalization compared to women with 4-year college degrees and above (HR: 2.01, 95% CI: 1.53 to 2.65). In the multivariable model, the least educated women had a 21% higher hazard of disease (HR: 1.21, 95% CI: 0.90 to 1.62) (Fig. 2B) compared to the most educated women.

Women >65 years of age accounted for 40.0% of the cohort (n = 10,463) and 63.5% (n = 412) of HF events.

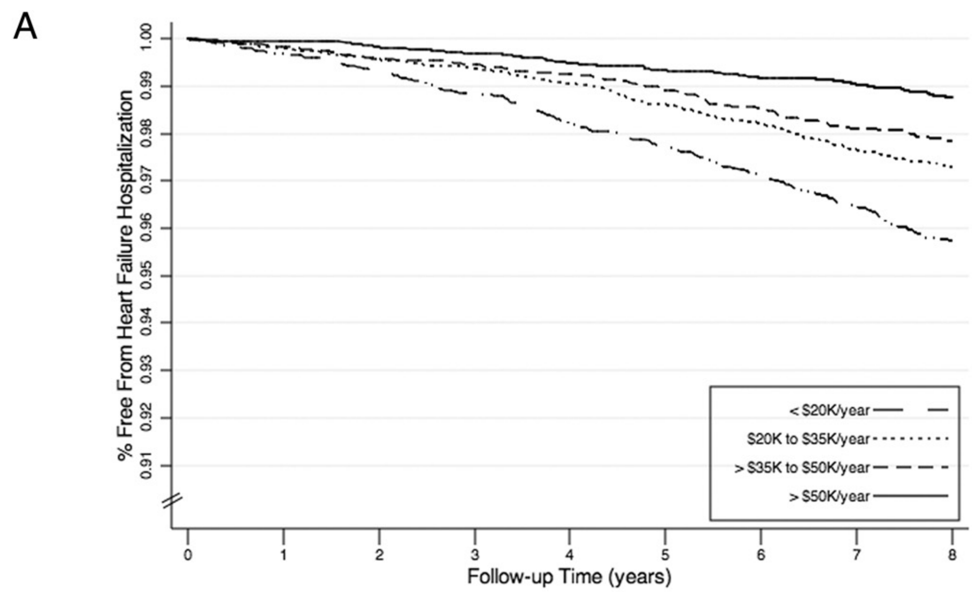
Table 2 Baseline Characteristics of Participants According to Income

Characteristics	<$20,000/Yr (n = 5,694)	$20,000/Yr to $34,999/Yr (n = 7,036)	$35,000/Yr to $49,999/Yr (n = 5,105)	>$50,000/Yr (n = 6,947)
Sociodemographic variables				
Age, yrs	64.6 ± 7.3	64.3 ± 7.0	63.1 ± 6.9	61.3 ± 7.0
Race/ethnicity				
White	3,945 (69.3)	5,868 (83.4)	4,348 (85.2)	5,972 (86.0)
Black	848 (14.9)	655 (9.3)	420 (8.2)	496 (7.1)
Hispanic	676 (11.9)	284 (4.0)	157 (3.1)	165 (2.4)
Asian/Pacific Islander	87 (1.5)	102 (1.5)	98 (1.9)	201 (2.9)
Other	117 (2.1)	116 (1.7)	74 (1.5)	101 (1.5)
Insurance type				
No insurance	1,466 (25.8)	713 (10.1)	325 (6.4)	281 (4.0)
Medicare	869 (15.3)	651 (9.3)	331 (6.5)	348 (5.0)
Medicaid	130 (2.3)	14 (0.2)	2 (0.04)	2 (0.03)
Medicare + Medicaid	129 (2.3)	11 (0.2)	4 (0.1)	7 (0.1)
Private insurance	1,459 (25.6)	3,292 (46.8)	2,961 (58.0)	4,837 (69.6)
Private + Medicare	1,556 (27.3)	2,312 (32.9)	1,454 (28.5)	1,432 (20.6)
Marriage status				
Never	256 (4.5)	287 (4.1)	198 (3.9)	170 (2.5)
Divorced	1,695 (29.8)	1,418 (20.2)	753 (14.8)	562 (8.1)
Widowed	2,022 (35.5)	1,617 (23.0)	724 (14.2)	530 (7.6)
Married	1,691 (29.7)	3,697 (52.5)	3,417 (66.9)	5,673 (81.7)
Behavioral/lifestyle variables				
Smoking status				
Never	2,870 (50.4)	3,516 (50.0)	2,529 (49.5)	3,407 (49.0)
Former smoker	1,958 (34.4)	2,713 (38.6)	2,043 (40.0)	2,871 (41.3)
Current	788 (13.8)	727 (10.3)	473 (9.3)	613 (8.8)
Alcohol use				
Nondrinker	997 (17.5)	883 (12.6)	537 (10.5)	553 (8.0)
Former drinker	1,592 (28.0)	1,490 (21.1)	807 (15.8)	860 (12.4)
0–7 drinks/per week	2,703 (47.5)	3,939 (56.0)	3,106 (60.8)	4,314 (62.1)
7+ drinks/per week	340 (6.0)	662 (9.4)	611 (12.0)	1,184 (17.0)
Physical activity				
No activity	1,215 (21.3)	1,273 (18.1)	904 (17.7)	989 (14.2)
Minimal activity	2,554 (44.9)	2,931 (41.7)	1,994 (39.1)	2,490 (35.9)
Moderate activity	603 (10.6)	987 (14.0)	759 (14.9)	1,150 (16.6)
Strenuous activity	809 (14.2)	1,229 (17.5)	1,027 (20.1)	1,735 (25.0)
Medical variables				
SBP ≥140 mm Hg, DBP ≥90 mm Hg, or treated HTN	2,585 (45.4)	2,906 (41.3)	1,955 (38.3)	2,237 (32.2)
Body mass index, kg/m^2	29.8 ± 6.3	29.3 ± 6.0	29.1 ± 6.0	28.2 ± 5.7
Diabetes mellitus	513 (9.0)	442 (6.3)	277 (5.4)	233 (3.3)
MI during follow-up	136 (2.4)	110 (1.6)	60 (1.2)	59 (0.9)
HRT				
Intervention	2,910 (51.1)	3,588 (51.0)	2,553 (50.0)	3,494 (50.3)
Placebo	2,781 (48.9)	3,448 (49.0)	2,553 (50.0)	3,453 (49.7)
Dietary modification				
Not randomized	4,066 (71.4)	4,932 (70.1)	3,533 (69.2)	4,884 (70.3)
Intervention	632 (11.1)	830 (11.8)	623 (12.2)	820 (11.8)
Control	996 (17.5)	1,274 (18.1)	950 (18.6)	1,244 (17.9)

Values are mean ± SD or n (%). All p values for the comparison of characteristics according to income group are significant at a level of $p < 0.01$, with the exception of hormone replacement therapy ($p = 0.53$) and dietary modification ($p = 0.03$).
Abbreviations as in Table 1.

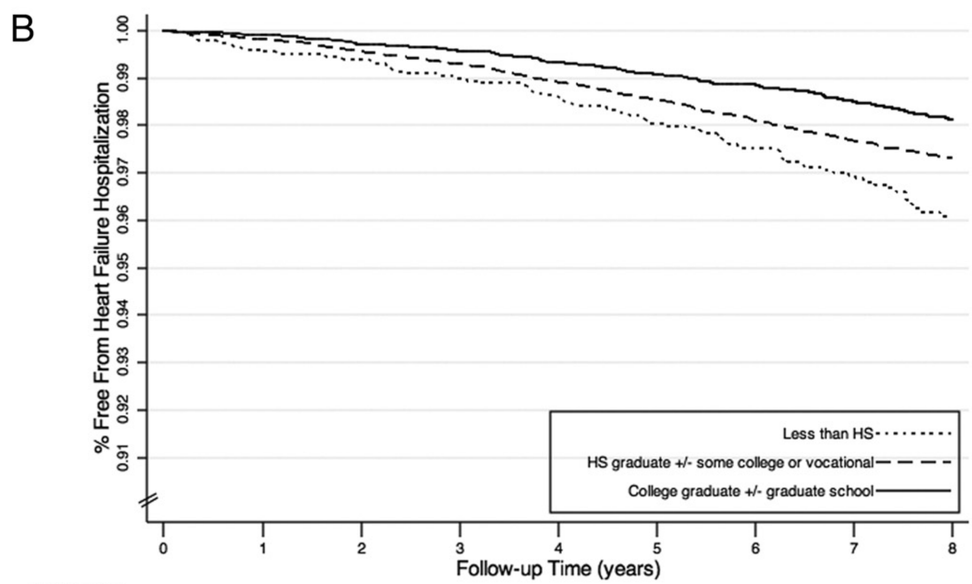
The hazard ratios for incident HF hospitalization between the lowest and highest income women were similar for both age groups (HR: 1.51, 95% CI: 0.97 to 2.34 for employment age; HR: 1.53, 95% CI: 1.08 to 2.16 for retirement age).

First-time HF hospitalization occurred in 2.5% of white women (n = 536) and 3.1% of black women (n = 84). The magnitudes of the effects of education and income were greater for black women, but nonsignificant due to small sample size (Table 3).



Number at risk

	0		1		2		3		4		5		6		7		8
< $20K/year	5694	(18)	5615	(19)	5534	(28)	5442	(35)	5326	(26)	5208	(33)	5073	(31)	4357	(28)	2605
$20K to $35K/year	7036	(14)	6984	(16)	6918	(14)	6827	(21)	6732	(29)	6624	(28)	6512	(36)	5594	(17)	3442
> $35K to $50K/year	5105	(9)	5065	(12)	5013	(7)	4981	(9)	4927	(18)	4860	(18)	4780	(20)	4057	(8)	2471
> $50K/year	6947	(3)	6913	(9)	6858	(9)	6800	(14)	6739	(10)	6675	(11)	6610	(10)	5717	(11)	3506



Number at risk

	0		1		2		3		4		5		6		7		8
Less than HS	2013	(8)	1984	(4)	1954	(8)	1922	(7)	1887	(11)	1842	(10)	1789	(10)	1541	(11)	906
HS graduate	15985	(29)	15836	(39)	15669	(44)	15473	(59)	15258	(58)	15018	(65)	14747	(62)	12635	(38)	7587
College graduate	8027	(8)	7985	(15)	7911	(11)	7849	(19)	7754	(19)	7653	(17)	7558	(27)	6481	(20)	4065

Figure 1 **Kaplan-Meier Curves for First-Time HF Hospitalization According to Income and Education**

(A) Kaplan-Meier curves for first-time heart failure (HF) hospitalization according to household income (log-rank test $p < 0.0001$ for comparisons): <$20,000/year **(broken line)**, 57.3/10,000 person-years (n = 234); $20,000 to $34,999/year **(dotted line)**, 38.5/10,000 person-years (n = 200); $35,000 to $49,999/year **(dashed line)**, 28.1/10,000 person-years (n = 106); and >$50,000/year **(solid line)**, 16.7/10,000 person-years (n = 87). **(B)** Kaplan-Meier curves for first-time HF hospitalization according to education level (log-rank test $p < 0.0001$ for comparisons): less than high school (HS) **(dotted line)**, 51.2/10,000 person-years (n = 74); high school graduate ± some college **(dashed line)**, 36.7/10,000 person-years (n = 429); 4-year college graduate ± any graduate school **(solid line)**, 25.5/10,000 person-years (n = 153).

JACC Vol. 58, No. 14, 2011
September 27, 2011:1457–64

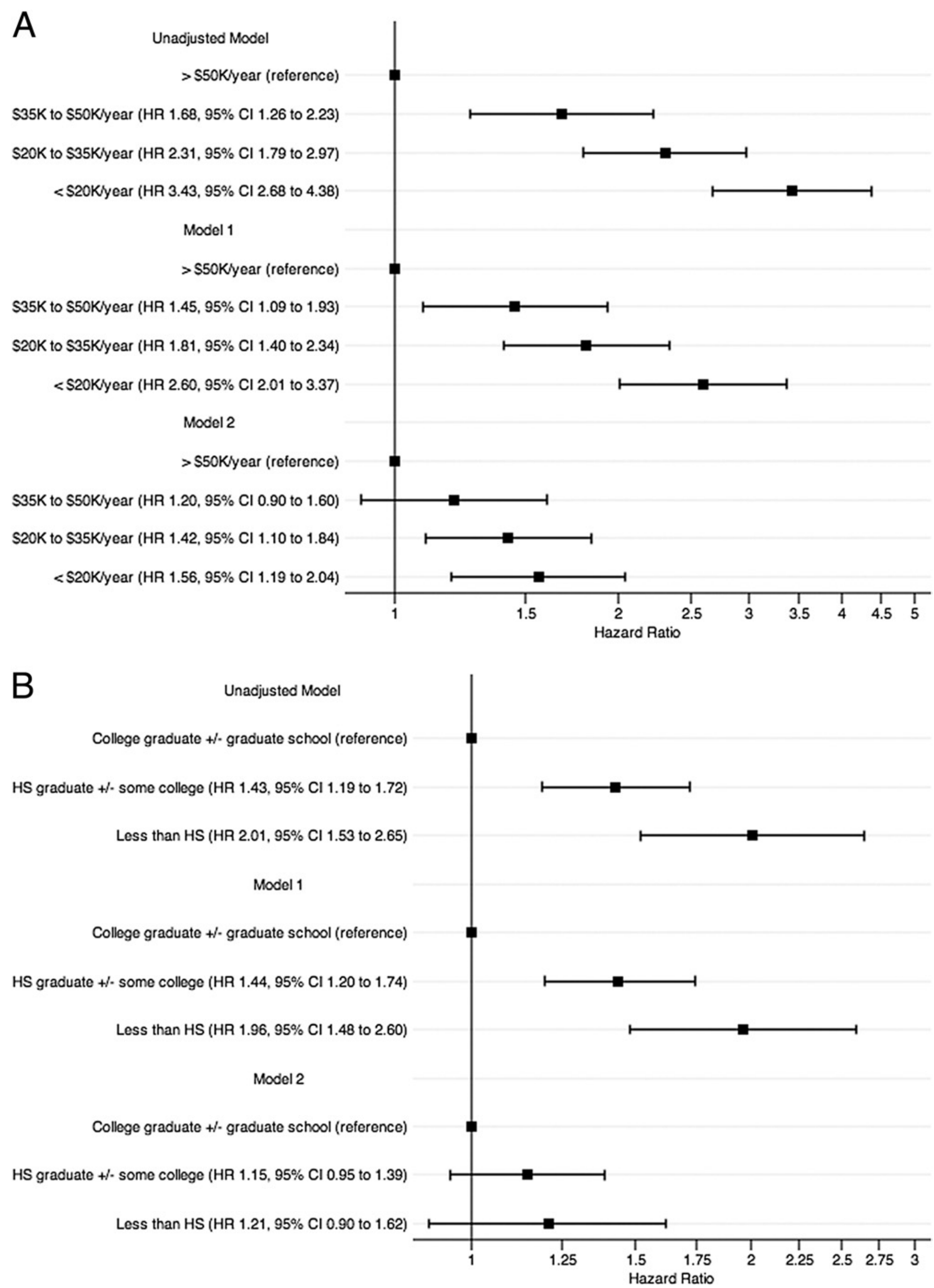


Figure 2 **HRs for First-Time HF Hospitalization According to Income and Education**

(A) Hazard ratios (HR) for first-time heart failure (HF) hospitalization according to household income. Model 1: age, race/ethnicity, marriage status, hormone assignment, dietary modification assignment. Model 2: preceding, plus level of physical activity, smoking status, alcohol consumption, body mass index, interim myocardial infarction, systolic blood pressure, treated hypertension, diabetes mellitus, health insurance. **(B)** HRs for first-time HF hospitalization according to education level. Model 1: age, race/ethnicity, marriage status, hormone assignment, dietary modification assignment. Model 2: preceding, plus level of physical activity, smoking status, alcohol consumption, body mass index, interim myocardial infarction, systolic blood pressure, treated hypertension, diabetes mellitus, health insurance. CI = confidence interval; HS = high school.

Discussion

Our investigation shows that incident HF hospitalization among post-menopausal women disproportionately affects women who have lower education attainment and income, regardless of race/ethnicity. Known risk factors for HF (8) were more prevalent among low SES women, consistent with prior investigations (9). However, the association of

Table 3 Regression Analysis of First-Time Heart Failure Hospitalization Risk on Education and Income, Stratified by Race/Ethnicity

	White Women (n = 21,269)		Black Women (n = 2,574)	
	HR	95% CI	HR	95% CI
Education				
Unadjusted model				
College graduate ± any graduate study (ref)	1.00	—	1.00	—
High school ± some college/vocational school	1.40	1.15–1.70	1.81	0.98–3.34
Less than high school	1.90	1.33–2.73	3.62	1.82–7.18
Multivariable model*				
College graduate ± any graduate study (ref)	1.00	—	1.00	—
High school ± some college/vocational school	1.10	0.76–1.60	2.11	1.02–4.34
Less than high school	1.15	0.94–1.41	1.37	0.73–2.56
Income				
Unadjusted model				
>$50,000/yr	1.00	—	1.00	—
$35,000 to $49,999/yr	1.62	1.20–2.20	1.87	0.72–7.29
$20,000 to $34,999/yr	2.29	1.76–3.00	1.63	0.67–4.00
<$20,000/yr	3.46	2.64–4.52	3.99	1.80–8.84
Multivariable model*				
>$50,000/yr	1.00	—	1.00	—
$35,000 to $49,999/yr	1.19	0.88–1.62	1.48	0.57–3.86
$20,000 to $34,999/yr	1.41	1.07–1.86	1.15	0.46–2.85
<$20,000/yr	1.69	1.26–2.26	2.26	0.97–5.23

*Multivariate model includes education or income, plus age, marriage status, dietary modification assignment, hormone therapy assignment, activity level, smoking status, alcohol consumption, body mass index, interim myocardial infarction, systolic blood pressure, treatment for hypertension, diabetes mellitus, and insurance.
CI = confidence interval; HR = hazard ratio.

lower income with first-time HF hospitalization risk persisted after adjustment for risk factors and other variables; adjustment attenuated the association with education, although the trend persisted.

Neighborhood characteristics, access to care, and health literacy may contribute to the SES disparity observed in our investigation. An investigation from the MESA (Multi-Ethnic Study of Atherosclerosis) study showed that decreasing levels of education and income were associated with unfavorable neighborhood characteristics: lack of walking environment, healthy food availability, safety, and social cohesion. The MESA study participants in these environments were more likely to have hypertension and high body mass index (10,11), known risk factors for HF.

A relationship between decreased preventive care access due to cost and higher disease incidence may contribute to SES disparities. Still, lower income patients who overcome financial barriers and seek out preventive care receive lower quality of care compared to higher income patients (12). Analysis from the Community Tracking Survey, a survey of health care utilization patterns, showed that low-income patients who had access to health care services received only 52% of recommended preventive services (13). One possibility is that copayments and deductibles prevent lower income patients from receiving care, even when insured, which may explain the stronger income effect we observed in this study.

Poor health literacy may affect low SES groups, and affects preventive care on many levels. Lower SES patients report poor communication with their doctors (12), and patients with low health literacy are less likely to seek preventive care (14). Advances in medical information technology could deepen the disparity conferred by low literacy (15).

Heart failure is a costly disease, with a total estimated cost of $37.2 billion in 2009; two-thirds of the cost comes from hospitalizations (16). Heart failure costs, mortality, and a growing at-risk population of elderly women are compelling reasons to design effective HF prevention programs for lower SES women (17). The Centers for Disease Control's Well-Integrated Screening and Evaluation for Women Across the Nation project showed that tailored outreach and prevention efforts can lead to improvements in blood pressure, cholesterol, and lifestyle habits among low-income, elderly women (18).

Study limitations. The WHI collected information on household income, rather than total wealth. This approach could lead to a misclassification of wealthy women who report low incomes. We addressed this possibility by a stratified analysis comparing retirement age women, who may have a discrepancy between reported income and total wealth, to employment age women; low income was associated with incident HF hospitalization in both groups. Moreover, most government agencies use the income metric, rather than wealth; use of income makes our results more useful for planning agencies.

We used only hospitalizations to identify incident HF events. Although this is a limitation, consideration of incident HF hospitalizations, relative to incident outpatient HF, is important because of associated disease severity and cost. Finally, the WHI includes healthy, post-menopausal women; our findings cannot be generalized to men and to younger women.

Conclusions

Our analysis of the WHI hormone trials show that post-menopausal women with lower SES are at increased risk for first-time HF hospitalizations, even after adjustment for known risk factors. As the U.S. population ages, with women as a larger proportion of the elderly population (17), tailored prevention efforts will help us alleviate the HF health care burden and this health disparity in the future.

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Key Words: heart failure ▪ socioeconomic status ▪ women.

APPENDIX

For supplemental tables and a list of WHI Investigators, please see the online version of this paper.