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Women, Loneliness, and Incident Coronary Heart Disease

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Abstract

Objective—To examine associations between loneliness and risk of incident coronary heart disease (CHD) over a 19-year follow-up period in a community sample of men and women. Loneliness, the perceived discrepancy between actual and desired social relationships, has been linked to several adverse health outcomes. However, no previous research has prospectively examined the association between loneliness and incident CHD in a community sample of men and women.

Methods—Hypotheses were examined using data from the First National Health and Nutrition Survey and its follow-up studies ($n = 3003$). Loneliness, assessed by one item from the Center for Epidemiologic Studies of Depression scale, and covariates were derived from baseline interviews. Incident CHD was derived from hospital records/death certificates over 19 years of follow-up. Hypotheses were evaluated, using Cox proportional hazards models.

Results—Among women, high loneliness was associated with increased risk of incident CHD (high: hazard ratio = 1.76, 95% Confidence Interval = 1.17–2.63; medium: hazard ratio = 0.98, 95% Confidence Interval = 0.64–1.49; reference: low), controlling for age, race, education, income, marital status, hypertension, diabetes, cholesterol, physical activity, smoking, alcohol use, systolic and diastolic blood pressures, and body mass index. Findings persisted additionally controlling for depressive symptoms. No significant associations were observed among men.

Conclusions—Loneliness was prospectively associated with increased risk of incident CHD, controlling for multiple confounding factors. Loneliness among women may merit clinical attention, not only due to its impact on quality of life but also its potential implications for cardiovascular health.

Keywords

coronary heart disease; cardiovascular disease; gender; women; loneliness; depression

INTRODUCTION

Multiple aspects of social and emotional functioning have been linked prospectively to cardiovascular outcomes. Among initially healthy individuals, those with smaller or less diverse social networks, lower perceived social support, and less frequent social interactions have increased risk of incident cardiovascular events and cardiovascular mortality (1). There is also evidence that more distressed or conflictual relationships may be associated with cardiovascular risk, particularly among women (1,2). Finally, negative emotional functioning,

including major depressive disorder and depressive symptoms, has been associated prospectively with cardiovascular events (1).

Loneliness has emerged as a key social-emotional factor linked to health outcomes. Although related to social isolation, loneliness is an aversive emotional response to a perceived discrepancy between desired and actual level of social interaction (3). Neither social network size nor frequency of social interactions generally differ between lonely and nonlonely people, but lonely individuals do rate their social interactions more negatively (4). Loneliness is characterized by emotional responses to perceived deficiencies in the social environment (3), and is distinct from social support which taps functional aspects of relationships (5). In one study, social networks, emotional support, and marital status together with demographic factors explained only 25% of the variance in loneliness (6). Finally, loneliness is distinct from depression. Although lonely feelings are common in depression (3), depression is a clinical syndrome encompassing emotional, behavioral, cognitive, and vegetative symptoms. Accordingly, loneliness is not universally included on depression measures nor is it included in the diagnosis of depressive disorder (7).

Loneliness has been linked to several adverse health outcomes. For example, endorsing "Yes" to "I feel lonely" was associated with increased 30-day and 5-year mortality among patients undergoing coronary artery bypass grafting (8), and a response of "Often" to the question "Do you feel lonely" was associated with increased cardiovascular mortality among men (9). High scores on the de Jong-Gierveld Loneliness Scale have been associated with increased mortality among older adults (10). Further, high loneliness scores on multiple item scales, such as the UCLA Loneliness Scale, have been linked to higher age-related increases in systolic blood pressure (SBP) (11), higher vascular resistance (12), poorer anti-body response to vaccine (13), poorer sleep efficiency (12), and adverse alterations in hypothalamic-pituitary-adrenal axis functioning (6,13). These associations are often independent of depression and/or objective social indicators (6,8,11,13,14). However, this research is largely cross-sectional, based on small samples, and assesses nonclinical health outcomes. There has been no prospective examination of loneliness and incident coronary heart disease (CHD) in community samples of men and women.

Gender is important to consider in relationships between loneliness and health, as poor quality relationships may be particularly deleterious to women's health. For example, whereas the simple presence of a spouse is linked to salubrious cardiovascular outcomes among men (2), marital quality seems important for women, with poor quality marriages linked to poor physical and mental health outcomes among women (1,2). Moreover, women may have a more interdependent self-concept (2) and have double the rates of depression compared with men (15). However, evidence for gender differences in loneliness (16) and its relationship to health (6,12) is mixed. In the Framingham Heart Study, loneliness as assessed by a single item asking about loneliness during the day was linked to cardiovascular events in a subset of women, although data for the full sample of women and men were lacking (17). Thus, any gender differences in the relationship between loneliness and incident CHD remain unclear.

The primary study aim was to examine associations between loneliness and risk of incident CHD over a 19-year period. We hypothesized that individuals reporting high loneliness would have increased incident CHD risk, independent of demographic and cardiovascular risk factors. Secondary aims were to examine 1) gender differences in the association between loneliness and incident CHD and 2) the role of depressive symptoms in associations between loneliness and CHD.

METHODS

Sample and Study Design

The First National Health and Nutrition Examination Survey (NHANES I) is a multistage, national probability survey conducted between 1971 and 1975 with the U.S. civilian noninstitutionalized population aged 1 to 74 years. It oversampled women of childbearing age, persons living in poverty areas, and elderly persons. The baseline assessment, conducted on the full cohort, included a medical examination, blood sample, and in-person structured interview. A representative subsample of adults aged 25 to 74 years ($n = 6913$) underwent more detailed medical and psychological assessments. A subset of this detailed sample ($n = 3003$) were administered the Center for Epidemiologic Studies of Depression scale (CESD) (18) when it was added to the baseline assessment battery for the last 35 of the 100 detailed sample study locations. Nonresponse rates are not available for the subset of the detailed sample that completed the CESD. However, nonresponse rates for the full detailed sample were 1.4% for the interview and 30.5% for the physical examination (19). Whereas interview nonresponders did not differ from participants on any demographic characteristics, examination nonresponders were older, had less education, and were more likely to reside in urban centers compared with responders ($p < .05$). Institutional Review Board approval, using current standards, was not obtained for NHANES I but internal human subject review within the National Center for Health Statistics was conducted. Details of study design and sampling procedures are published elsewhere (20).

In 1982, 1987, and 1992, follow-up studies were conducted on the full surviving NHANES I cohort aged 25 to 74 years at the baseline examination, and in 1986 on participants aged 55 to 74 years at baseline (19,21,22). Assessments included an interview with the respondent or proxy (for decedents), measurements of weight and blood pressure, tracking of participants via National Death Index and acquisition of death certificates, and obtainment of all records for overnight hospital and nursing home stays in the study period. All members of the detailed sample were traced at one or more follow-ups.

The present investigation included members of the detailed subsample who were administered the CESD at the NHANES I baseline ($n = 3003$). Among these individuals, those with a history of cardiovascular disease by self-report or physical examination at baseline ($n = 201$) and missing values for one or more covariates assessed at baseline ($n = 186$) were excluded from primary analyses. Participants with missing data were more likely to be male ($p < .001$) and to have a lower body mass index (BMI) ($p = .02$) relative to those without missing data. The final sample available for primary analyses included 2616 participants ($n = 1150$ men, 1466 women). Secondary analyses included a social networks measure assessed at the 1982 interview, and loneliness ratings obtained at both baseline and 1982 interviews excluded an additional 563 and 568 individuals, respectively. Individuals missing 1982 data were older ($p < .05$), lonelier ($p = .01$), more depressed ($p < .05$), less educated ($p < .001$), had higher SBP ($p < .05$), and were more often non-white ($p = .005$), unmarried ($p < .001$), diabetic ($p = .004$), and smokers ($p < .001$) than those not missing 1982 interview data.

Measures

Loneliness Loneliness was derived from an item on the CESD (18) administered during the baseline NHANES I interview. Participants were asked to rate the statement: "I feel lonely" on a 4-point scale: Rarely or none of the time (<1 day), some or a little of the time (1–2 days), occasionally or a moderate amount of the time (3–4 days), or most of the time (5–7 days) in the past week. Due to small cell sizes and the categorical nature of this measure, scores were categorized as low (<1 day), medium (1–2 days), and high (3–7 days) for primary analyses.

The CESD was again administered to the detailed sample during the 1982 interview, an average of 8.2 (SD = 0.6; range = 6.7–9.7) years after baseline. Answers to this loneliness item were used with the baseline responses to characterize loneliness across the two visits in secondary analyses to assess the consistency of associations over time. Those reporting low loneliness at both interviews were classified as low loneliness, those reporting high loneliness at either interview were classified as high loneliness, and the remainder were classified as having moderate levels of loneliness across time points.

Incident CHD CHD events were identified via hospital/nursing home discharge reports and death certificates. At each follow-up, participants reported all hospital or nursing home stays from the time of the last study contact. Hospitals/nursing homes were contacted with participant permission, and discharge reports were obtained for all overnight stays in the study period. All decedents were tracked via the National Death Index and death certificates obtained. A CHD event was coded if International Classification of Diseases, Ninth Revision (ICD-9) codes 410 to 414 (ischemic heart disease) were listed on the discharge report or as the cause of death on the death certificate. For nonfatal events, the event date was the discharge date. If no discharge date was available, the admission date was used. For fatal events, the event date was the date of death on the death certificate. In the case of multiple events (e.g., myocardial infarction followed by CHD death), the first event was considered as the event and the participant was thereafter censored. Results were also considered excluding ICD-9 codes 412 (old myocardial infarction) and 413 (angina), restricting events to ICD-9 codes 410 (acute myocardial infarction), 411 (other acute/subacute ischemic heart disease), and 414 (other chronic ischemic heart disease). Because results were largely unchanged, results utilizing ICD-9 codes 410 to 414 are presented here.

Covariates Gender, education, household income, marital status, and depressive symptoms were derived from responses to the baseline NHANES I interview. Race/ethnicity, initially interviewer-identified in NHANES I, was self-identified by the participant in all subsequent NHANES interviews, with 1982 updated values used here (19). Approximately 90.6% ($n = 2369$) of participants reported being white, 8.3% ($n = 217$) black, 0.5% ($n = 13$) Asian, 0.5% ($n = 13$) Native American, and 0.2% ($n = 4$) other race/ethnicity. Due to small cell sizes across several groups, participants were classified as white or non-white. Education was categorized into levels of attainment (<high school, high school graduate, some college, college graduate). Household income was considered relative to 1973 (median year of NHANES I examination) poverty thresholds for reported family size (<100%, 100%–200%, >200% of the poverty threshold). For example, if a household income is less than the poverty threshold, they were identified as <100% of this threshold, and thereby considered to be in poverty. At 100% to 200% of the poverty threshold, individuals are considered to be just above the poverty threshold with an income equal to or twice the threshold. Marital status was classified as married or unmarried (single, widowed, divorced, separated; study findings were similar when marital status was categorized in more detail). Depressive symptoms were obtained from the depressed mood subscale of General Well-Being Schedule, a validated measure with known psychometric properties (23), which has been linked to incident CHD in this sample (24). This measure included no items about loneliness.

Alcohol use (none, 1–2 servings/day, >2 servings/day), leisure time physical activity (sedentary/light, moderate, or regular exercise), smoking status (current versus never/former), and hypertension or diabetes status (past or present doctor-diagnosis and/or past or present medication use for the condition) were derived from responses to the baseline interview. SBP and diastolic blood pressure values were obtained from one seated measurement taken during the baseline physical examination. Total serum cholesterol levels were determined from blood drawn and BMI (weight (kg)/height (m)²) from measures taken during this examination.

The 1982 follow-up interview included the question, "In general, how many relatives and friends do you have that you feel close to? These are people whom you feel at ease, can talk to about private matters, and can call on for help" (response options: 0, 1, 2, 3, 4, 5, 9, 10, 19, or 20). This question was used as a proxy measure of social networks to ensure that effects of loneliness are not simply reiterating the well-known relationship between social networks and disease (1). It is limited, however, by some conceptual overlap with the loneliness measure, as illustrated by their significant but weak inverse correlation ($r = -0.14, p < .001$).

Statistical Analyses

Variations in demographic and risk factors by loneliness category were calculated using χ^2 tests and analysis of variance. Gender differences in loneliness were estimated with ordinal logistic regression models. Hazard ratios (HRs) and 95% Confidence Intervals (CIs) of incident CHD associated with loneliness were estimated in multivariate Cox proportional hazards regression models. Time from baseline to the CHD event date, non-CHD death date, or the last date known alive was the follow-up time. Models were first estimated examining baseline loneliness in relation to incident CHD, adjusted for age, race, and gender. Subsequently, demographic, biological, and behavioral variables known to be related to CHD risk, including educational attainment, household income, marital status, smoking, aerobic exercise, alcohol use, SBP, diastolic blood pressure, BMI, cholesterol, hypertension, and diabetes status were added to models. Models were additionally adjusted for depressive symptoms or social networks. Interactions between loneliness and CHD by gender were examined. Where a significant interaction was evident, results were presented by gender. Models were repeated with the composite loneliness measure across baseline and 1982 interviews. For models using this composite loneliness measure, individuals experiencing a CHD event (or censoring) before 1982 were excluded. Analyses were conducted using SAS V8.2 (SAS Institute, Cary, North Carolina). All tests were two-sided at $\alpha = 0.05$.

RESULTS

Over the follow-up period (mean = 14.9, standard deviation = 5.1, range = 0–18.9 years), 357 incident CHD events ($n = 237$ nonfatal, 120 fatal) were recorded via hospital/nursing home records and death certificates. Loneliness was associated with younger age, unmarried status, less exercise, lower cholesterol, fewer friends/relatives, and higher depressive symptoms (Table 1). Loneliness showed a strong socioeconomic gradient, highest among those with lower income and educational attainment. Women had over two-fold odds of elevated loneliness ratings relative to men (OR = 2.32, 95% CI = 1.92–2.81). In addition, women had higher depressive symptoms ($p < .001$), lower SBP ($p = .003$), lower diastolic blood pressure ($p < .001$), lower BMI ($p = .001$), lower income ($p < .001$), and lower education ($p = .002$); drank less alcohol ($p < .001$); were more likely to be unmarried ($p < .001$) or hypertensive ($p = .002$), and less likely to smoke ($p = .001$) than men.

Relative to low loneliness, high loneliness was associated with significantly increased risk of incident CHD in age, race, and gender-adjusted models (high: HR = 1.67, 95% CI = 1.20–2.32; medium: HR = 0.91, 95% CI = 0.66–1.25; reference: low). Results persisted in models additionally adjusted for education, income, marital status, SBP, diastolic blood pressure, hypertension, diabetes, BMI, cholesterol, alcohol use, exercise, and smoking (high: HR = 1.50, 95% CI = 1.07–2.10; medium: HR = 0.89, 95% CI = 0.64–1.24; reference: low), as well as with the addition of depressive symptoms (high: HR = 1.53, 95% CI = 1.07–2.21; medium: HR = 0.90, 95% CI = 0.64–1.27; reference: low). Results were consistent when considering loneliness as a continuous measure in these models adjusted for demographic factors, risk factors, and depressive symptoms (HR = 1.19, 95% CI = 1.02–1.38). Figure 1 depicts the estimated survival functions from the Cox model of event-free CHD time by loneliness

category, with low and medium groups combined due to the similarity in parameter estimates for these groups.

A significant interaction by gender was observed ($p = .02$), with loneliness associated with incident CHD among women, but not men. Results persisted among women with further adjustment for covariates, and additionally depressive symptoms (Table 2). Findings persisted among women when controlling for the social network measure in multivariable models (high: HR = 1.81, 95% CI = 1.20–2.94; medium: HR = 0.98, 95% CI = 0.60–1.61; reference: low). We note an apparent threshold effect, with elevated CHD risk apparent only in the high lonely category. However, when the loneliness measure was considered as a continuous variable in models adjusted for demographics, risk factors, and depressive symptoms, it did remain significant among women (HR = 1.26, 95% CI = 1.04–1.51). No associations between loneliness and CHD were observed among men.

Several additional analyses were conducted. Loneliness ratings across baseline and 1982 visits were correlated at $\tilde{r} = 0.27$, $p < .001$ across men and women. Analyses of loneliness across baseline and 1982 surveys in relationship to CHD showed findings consistent with baseline results. Specifically, women reported higher loneliness across the two time points relative to men (OR = 2.32, 95% CI = 1.92–2.81), and among women only, loneliness across time points was associated with incident CHD in minimally adjusted models (high: HR = 2.10, 95% CI = 1.32–3.31; medium: HR = 1.19, 95% CI = 0.72–1.97; reference: low), models adjusted for demographic and cardiovascular risk factors (high: HR = 1.98, 95% CI = 1.23–3.19; medium: HR = 1.08, 95% CI = 0.64–1.84; reference: low), and multivariable models additionally controlling for depressive symptoms (high: HR = 1.90, 95% CI = 1.12–3.21; medium: HR = 1.07, 95% CI = 0.63–1.82; reference: low) or social networks (high: HR = 1.96, 95% CI = 1.22–3.16; medium: HR = 1.08, 95% CI = 0.64–1.83; reference: low).

Second, to address the possibility that lonely individuals may have had poorer baseline health not captured by measured variables and accounting for observed results, all analyses were repeated excluding the first 3 years of follow-up. Conclusions were unchanged.

Third, we considered fatal versus nonfatal incident CHD events separately. Among women, associations remained significant for fatal and nonfatal events in age and race-adjusted models, with more robust associations for fatal (high: HR, 3.22, 95% CI 1.68–6.18; medium: HR, 1.26, 95% CI 0.62–2.58; reference: low) versus nonfatal (high: HR = 1.71, 95% CI = 1.05–2.80; medium: HR = 0.97, 95% CI = 0.60–1.58; reference: low) events. Further, we considered interactions between depressive symptoms and loneliness, which were nonsignificant for men and women. We also considered the loneliness item controlling for the rest of the CESD in age and race-adjusted models, and although findings should be interpreted with caution due to issues of collinearity, loneliness remained significantly associated with CHD among women (high: HR = 1.69, 95% CI = 1.02–2.81; medium: HR = 0.93, 95% CI = 0.60–1.42; reference: low).

Finally, given prior evidence of interactions between age and loneliness in relationship to SBP (11), interactions between age and loneliness were examined in relationship to CHD; no significant interactions were observed.

DISCUSSION

This is the first investigation to examine loneliness in relationship to incident CHD in a large population-based sample of men and women initially free of cardiovascular disease. The present investigation indicated that, among women, loneliness was associated with incident CHD events over a maximum of 19 years of follow-up. These associations persisted with adjustment for demographic, behavioral, and biological risk factors as well as for depressive

symptoms. Moreover, findings persisted controlling for the number of close friends and relatives. Finally, results were consistent when loneliness was considered across two time points. No significant associations were observed among men.

Loneliness is defined as distressing emotions arising from the perceived discrepancy between actual and desired relationships (3). Given the emphasis on subjective appraisals of and emotional responses to relationships, loneliness is often elevated among depressed individuals who have more negative appraisals of their world (3). Accordingly, loneliness and depression may each increase risk for the other over time (3,25). Depression, in turn, has been related to CHD (1), including the present sample (24). In this study, lonely individuals did report higher depressive symptoms than individuals who were not lonely. However, findings among women persisted relatively unchanged, after controlling for depressive symptoms. Notably, there is substantial debate concerning what element of depression is most *cardiotoxic*. Although this study was not designed to address that question, it does suggest that loneliness, a construct related to but independent of depression, deserves further attention in relationship to CHD.

Loneliness is distinct from objective social indicators, including marital status, social network size, or frequency of social contact (3,12). Loneliness taps the negative emotional experience of isolation that may be unrelated to objective social conditions (12). In the present study, although lonely individuals were more likely to be unmarried and to have fewer people in their life to whom they felt close, associations between loneliness and CHD among women persisted, controlling for these social conditions. This finding is particularly striking because the social network item available in the present study has more conceptual overlap with loneliness than traditional network measures.

Associations between loneliness and CHD were observed among women only. Women had over two-fold odds of being lonely relative to men, and only 62 men reported high loneliness. Therefore, lack of associations among men is likely due to the underrepresentation of men in high loneliness categories, precluding firm conclusions about loneliness and CHD among men. Previous findings of gender differences in loneliness have been conflicting. Men score lower in response to items directly measuring feelings of loneliness, but they score similarly to women on loneliness scales not involving self-labeling as lonely (16). Men may be more reluctant than women to report loneliness because they are viewed more negatively when they do (16).

Results utilizing loneliness ratings from baseline alone or from both baseline and 1982 surveys were comparable. In both analyses, high loneliness at one or across time points was associated with increased CHD risk. Although the single-item measure, low-assessment frequency, and modest correlation between assessments across time limited the precise quantification of loneliness, these analyses suggested that findings were not contingent on responses at a single time point or approach to quantifying loneliness. Future work should further examine the duration of exposure to loneliness most relevant to CHD risk.

There are multiple mechanisms by which loneliness may relate to CHD. Whereas behavioral factors may be one important pathway, several investigations reported inconsistent or no relationships between health behaviors and loneliness (4,6,12). Consistent with this work, in this investigation for the sample as a whole, loneliness was related to lower levels of physical activity, but no other health behaviors. However, among women only, loneliness was associated with smoking, sedentary behavior, and marginally with overweight or obesity (data not shown). Moreover, loneliness has been linked to additional pathophysiologic processes not assessed here, such as higher total peripheral vascular resistance and lower cardiac output (4, 12), which have been linked to hypertensive vascular and cardiac remodeling (26). Lonely individuals have also shown adverse alterations in hypothalamic-pituitary-adrenal axis functioning (6,13), increased fibrinogen in response to laboratory stressors (6), impaired

expression of anti-inflammatory glucocorticoid response genes, increased activity of proinflammatory transcription control pathways (14), and poorer sleep quality and efficiency (6,12), all of which have been implicated as links between psychosocial factors and CHD (27).

The study findings should be interpreted in light of several limitations. First, loneliness was assessed with a single item rather than a full scale. Therefore, it likely did not capture the full breadth of the loneliness construct, and its derivation from a depression scale does impose some interpretative limitations. However, this item likely did tap loneliness, as a similar item asking respondents to rate the degree of current feelings of loneliness correlated highly with the widely used UCLA Loneliness Scale ($r = .79$) (28), and similar single-item indices (e.g., "Do you feel lonely?" "I feel lonely") have been predictive of health outcomes in prior work (8,9,12,17,29). An advantage to this single item is its face validity. Notably, most widely used multiple-item scales do not directly ask respondents about feelings of loneliness (28,30). In addition, the representation of racial/ethnic minority groups was low, and associations should be investigated in more diverse samples. Furthermore, analyses considering social networks or loneliness across two time points had smaller samples due to data limitations, and those missing data at the second time point were the more disadvantaged and in worse mental and physical health. Therefore, analyses of social networks or loneliness across time points excluded the highest-risk individuals, although this exclusion would make detection of significant associations less likely in these secondary analyses. Analyses using baseline and 1982 loneliness ratings are secondary in nature, presented to inform future investigation rather than to provide definitive findings on loneliness chronicity in relationship to CHD, as two time points do not allow quantification of exposure to loneliness over the entire follow-up period. Nonresponse rates were available for the full cohort and the detailed sample, but not for the subsample of individuals receiving the CESD. Therefore, any bias introduced by non-response may not have been fully quantified. Finally, it is possible that some unmeasured third factor (e.g., genetic polymorphism) accounts for both greater loneliness and CHD risk.

This study had several strengths. It was a large population-based prospective investigation including men and women. Individuals with cardiovascular disease at baseline, established by physical examination, were excluded. CHD events were tracked prospectively up to 19 years and quantified via medical record or death certificates. Finally, associations were investigated at the same time considering a range of demographic, biological, behavioral, and psychological factors linked to CHD.

This investigation indicated that high loneliness was associated with increased risk of incident CHD among women. These associations could not be explained by differences in demographic factors, other social indicators, biological or behavioral risk factors, or depressive symptoms. These associations were not apparent among men. Thus, results suggest that elevated loneliness among women may merit increased clinical attention, not only with respect to its deleterious impact on quality of life but also given its potential implications for cardiovascular health.

Glossary

CHD	coronary heart disease
SBP	systolic blood pressure
NHANES I	First National Health and Nutrition Examination Survey
CESD	Center for Epidemiologic Studies of Depression
BMI	body mass index

ICD-9

International Classification of Diseases, Ninth Revision

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Figure 1.
Loneliness and incident CHD, adjusted for age, race, and gender. CHD, coronary heart disease.

TABLE 1

Sample Characteristics by Loneliness Rating

	Loneliness			<i>p</i>
	Low (<i>n</i> = 1966)	Medium (<i>n</i> = 409)	High (<i>n</i> = 241)	
Age, mean (SD), years	45.3 (13.6)	43.0 (13.4)	44.0 (13.8)	.005
Gender, <i>n</i> (row %)				
Male	960 (83.5)	128 (11.1)	62 (5.4)	<.001
Female	1006 (68.6)	281 (19.2)	179 (12.2)	
Race, <i>n</i> (row %)				
White	1790 (75.6)	368 (15.5)	211 (8.9)	.20
Non-white	176 (71.3)	41 (26.6)	30 (12.2)	
Education, <i>n</i> (row %)				
<High school	585 (72.9)	119 (14.8)	99 (12.3)	.003
High school	759 (77.5)	140 (14.3)	81 (8.3)	
Some college	308 (74.8)	70 (17.0)	34 (8.3)	
College	314 (74.6)	80 (19.0)	27 (6.4)	
Income, <i>n</i> (row %) ^a				
<100% poverty	158 (63.0)	51 (20.3)	42 (16.7)	<.001
100%–200% poverty	311 (67.3)	84 (18.2)	67 (14.5)	
>200% poverty	1497 (78.7)	274 (14.4)	132 (6.9)	
Marital status, <i>n</i> (row %)				
Married	1638 (78.9)	286 (13.8)	152 (7.3)	<.001
Unmarried	328 (60.7)	123 (22.8)	89 (16.5)	
Alcohol use, <i>n</i> (row %)				
None	436 (77.0)	79 (14.0)	51 (9.0)	.21
1–2 servings/day	1390 (74.7)	306 (16.4)	166 (8.9)	
>2 servings/day	140 (74.5)	24 (12.8)	24 (12.8)	
Exercise status, <i>n</i> (row %)				
None–little	523 (67.6)	150 (19.4)	101 (13.0)	<.001
Moderate	991 (78.0)	188 (14.8)	91 (7.2)	
High	452 (79.0)	71 (12.4)	49 (8.6)	
Current smoker, <i>n</i> (%) yes	763 (38.8)	160 (39.1)	110 (45.6)	.12
Depressive symptoms, mean (SD)	5.0 (3.6)	8.4 (3.9)	12.0 (5.3)	<.001
Median number of friends/relatives	5–9	3–4	3–4	<.001
BMI, mean (SD)	25.4 (4.8)	25.0 (5.0)	25.6 (5.4)	.15
Total cholesterol, mean (SD), mg/dL	220.0 (45.5)	214.4 (43.6)	215.1 (46.1)	.04
Hypertension, <i>n</i> (%) yes	282 (14.3)	59 (14.4)	47 (19.5)	.10
Diabetes, <i>n</i> (%) yes	65 (3.3)	17 (4.2)	13 (5.4)	.22
SBP, mean (SD), mm Hg	129.0 (19.9)	127.0 (18.9)	128.7 (21.5)	.17
DBP, mean (SD), mm Hg	84.8 (11.4)	83.5 (11.3)	84.9 (12.5)	.12

^aBased on 1973 poverty thresholds for family size.

SD = standard deviation; SBP = systolic blood pressure; DBP = diastolic blood pressure.

TABLE 2

Association Between Loneliness and Incident CHD by Gender

	Women (n = 1466)			Men (n = 1150)		
	Model 1 ^a HR (95% CI)	Model 2 ^b HR (95% CI)	Model 3 ^c HR (95% CI)	Model 1 ^a HR (95% CI)	Model 2 ^b HR (95% CI)	Model 3 ^c HR (95% CI)
Loneliness						
$\tilde{A}\tilde{A}$ Low		$\tilde{A}\tilde{A}$	$\tilde{A}\tilde{A}$	$\tilde{A}\tilde{A}$	$\tilde{A}\tilde{A}$	$\tilde{A}\tilde{A}$
$\tilde{A}\tilde{A}$ Medium	1.06 (0.71 $\tilde{A}$ 1.59)	0.98 (0.64 $\tilde{A}$ 1.49)	1.01 (0.65 $\tilde{A}$ 1.57)	0.78 (0.46 $\tilde{A}$ 1.33)	0.85 (0.50 $\tilde{A}$ 1.47)	0.81 (0.46 $\tilde{A}$ 1.42)
$\tilde{A}\tilde{A}$ High	2.11 (1.43 $\tilde{A}$ 3.12)	1.76 (1.17 $\tilde{A}$ 2.63)	1.87 (1.19 $\tilde{A}$ 2.94)	0.98 (0.50 $\tilde{A}$ 1.92)	0.93 (0.47 $\tilde{A}$ 1.85)	0.88 (0.43 $\tilde{A}$ 1.78)

^a Covariates = age, race.

^b Covariates = age, race, education, income, marital status, hypertension, diabetes, systolic blood pressure, diastolic blood pressure, body mass index, cholesterol, physical activity, smoking, alcohol use.

^c Covariates = age, race, education, income, marital status, hypertension, diabetes, systolic blood pressure, diastolic blood pressure, body mass index, cholesterol, physical activity, smoking, alcohol use, depressive symptoms.

CHD = coronary heart disease; HR = hazard ratio; CI = Confidence Interval.