THE LINK BETWEEN SOCIAL ISOLATION AND INFLAMMATION:
DIMENSIONS, MEASURES, AND MECHANISMS, *

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SOCIAL ISOLATION GETS UNDER THE SKIN:

OBJECTIVE AND SUBJECTIVE ISOLATION AND INFLAMMATION

ABSTRACT

Social isolation has been linked to poor mental and physical health and mortality, but we know little about the physiological processes that underlie this association. This paper examines one important potential pathway between social isolation and health. The stress response leads to short-run increases in blood pressure that may damage arterial walls in the long-run, leading to hypertension and inflammation. Inflammation is now thought to be a root cause of a number of diseases, especially cardiovascular disease. We use data from the 2005-6 National Social Life, Health and Aging Study, to model the effect of key dimensions of social isolation on systolic blood pressure and C-Reactive Protein, a marker of inflammation. We also model effects of isolation through several measures of emotional well-being and through health behaviors, and assess gender differences in these relationships.

Social Isolation Gets Under the Skin: Objective and Subjective Isolation and Inflammation*

Recent research suggests great heterogeneity in levels of social connectedness among older adults. Life events and health changes lead some older adults to experience decreasing social connectedness, but social participation enables others to replace lost ties or to compensate for infrequent social interaction. The relationship between aging and social isolation is important, particularly when we consider the implications of social connectedness for health. Health risks associated with social isolation have been compared in magnitude to the well-known risks of smoking cigarettes and obesity (House 2001). In fact, numerous aspects of isolation have been linked to all-cause mortality, increased morbidity, diminished immune function, depression, and cognitive decline (Barnes, Mendes de Leon, Wilson, Bienias, and Evans 2004; Brummett, Barefoot, Siegler, Clapp-Channing, Lytle, Bosworth, Williams, and Mark 2001; Seeman 2000; Uchino, Cacioppo, and Kiecolt-Glaser 1996).

Although later life is not always characterized by social isolation, the health risks of social isolation loom especially large for older adults. Retirement, bereavement, and the development of health problems are more common within older age groups. These life changes pose significant challenges to the maintenance of social relationships at the same time that they increase the importance of support and companionship. Older adults who lack social ties, feel lonely, or perceive little social support face particularly high risks of physical and mental health problems (Brummett et al. 2001; Cacioppo and Hawkley 2003; Tomaka, Thompson, and Palacios 2006). However, by optimizing existing relationships or adjusting expectations, some older adults manage to dissociate low levels of social connectedness from feelings of loneliness or perceived deficits in support (Baltes and Carstensen 1996; Schnittker 2007).

We use data from the National Social Life, Health, and Aging Project (NSHAP), a population-based study of 3,005 community-residing older adults conducted in 2005-2006. This data set includes detailed indicators of objective isolation and subjective isolation along with biomeasures of key steps in the inflammatory process. The data also include measures of psychosocial states and health behaviors, both of which are theoretically important in the processes linking social isolation to health.

SOCIAL ISOLATION AMONG OLDER ADULTS

Older adults who experience one or another aspect of social isolation are at greater risk for all-cause mortality, increased morbidity, diminished immune function, depression, and cognitive decline (Barnes et al. 2004; Brummett et al. 2001; House 2001; Seeman 2000; Uchino, Cacioppo, and Kiecolt-Glaser 1996). A wide variety of indicators of social isolation have been identified as threats to older adults' health and well-being, including living alone (Dean, Kolody, Wood, and Matt 1992; Hughes and Gove 1981; Klinenberg 2002), being unmarried (Lillard and Waite 1995), having a small social network (Berkman and Syme 1979; Seeman, Berkman, Blazer, and Rowe 1994), infrequent contact with network members (Brummett et al. 2001), and a lack of social network diversity (Barefoot, Gronbaek, Jensen, Schnohr, and Prescott 2005; Haines and Hurlbert 1992). Low levels of participation in social activities are also associated with worse health outcomes (Benjamins 2004; Ellison and George 1994; Thoits and Hewitt 2001).

At the same time, feelings of loneliness or not belonging (Cacioppo, Hughes, Waite, Hawkley, and Thisted 2006; Hawkley, Burleson, Berntson, and Cacioppo 2003), and a perceived lack of social support (Blazer 1982; Krause 1987; Lin, Ye, and Ensel 1999) are health risks often examined in social psychological research.

Objective and Subjective Social Isolation

Social isolation may manifest in two forms: objective social isolation and subjective social isolation (c.f., Caplan 1979; de Jong Gierveld and Hagestad 2006; Lin, Ye, and Ensel 1999; van Tilburg, de Jong Gierveld, Lecchini, and Marsiglia 1998). *Objective social isolation* is characterized by a lack of contact with others. It is indicated by situational factors, like a small or restricted social network, infrequent social interaction, and lack of participation in social activities and groups. *Subjective social isolation*, on the other hand, is characterized by a perceived shortfall in one's social resources, such as companionship and social support. Loneliness and its corollary feelings of disconnectedness and not belonging, for example, indicate a perceived inadequacy of the intimacy or companionship of one's interpersonal relationships compared to the relationships that one would like to have (van Baarsen, Snijders, Smit, and van Duijn 2001). Subjective appraisals of one's social resources do not simply reflect the situational realities of one's objective social connectedness. They are informed by personality and other individual-level characteristics (Steptoe et al 2004), such as neuroticism (Stokes 1985) and cognitive schemas (Lakey and Cassady 1990). Some research suggests that just under half of the variation in loneliness across individuals is heritable (Boomsma, Willemsen, Dolan, Hawkley, and Cacioppo 2005).

Health-Related Consequences of Objective and Subjective Isolation

More importantly, objective and subjective isolation may have distinct associations with particular aspects of physical and mental health, as they may affect health through different mechanisms. Objective aspects of social connectedness, like social network size and social participation, can provide access to material resources such as health care information, transportation, financial loans, or emotional support (Ellison and George 1994; Haines and

Hurlbert 1992; Lin 2001). Aspects of objective social connectedness such as integration within dense social networks may also directly or indirectly promote healthy behaviors and discourage health risks, ultimately leading to better health outcomes (Kinney, Yeomans, Bloor, and Sandler 2005; Rook and Ituarte 1999; Umberson 1987). Of course, social relationships are not always and everywhere beneficial. Stressful family relationships have been linked to worse health outcomes, for example, (Umberson, Williams, Powers, Liu, and Needham 2006; Wickrama, Lorenz, Wallace, Peiris, Conger, and Elder 2001) and health-risk behaviors such as smoking, risky sexual behavior, and poor diet can be diffused through social networks (Christakis and Fowler 2007; Latkin, Forman, Knowlton, and Sherman 2003). However, older adults who have few relationships and infrequent contact with family and friends may suffer worse health outcomes because they have less access to the potential benefits and resources provided by social relationships.

Subjective isolation is usually linked to health outcomes through different mechanisms. Unlike objective isolation, subjective isolation (particularly in the form of loneliness) does not appear to affect health through the modification of health-related behaviors (Hawkley, Burleson, Berntson, and Cacioppo 2003; Seeman 2000; Steptoe, Owen, Kunz-Ebrecht, and Brydon 2003). However, a large body of research demonstrates a particularly strong correlation between subjective isolation and mental health problems, especially depression (Weeks, Michela, Peplau, and Bragg 1980). Loneliness is a key predictor of depression among older adults (Cacioppo et al. 2006; Heikkinen and Kauppinen 2004). Similarly, perceived social support is more important for mental health outcomes than are objective aspects of isolation such as received social support (Krause 1987; Wethington and Kessler 1986) and social network size (Brummett et al. 2001).

In this sense, subjective isolation appears to work mainly through emotional and psychological mechanisms to affect physical health. For example, depressive symptoms increase

the chances of disregulation of physiological process such as inflammation (Toker, Shirom, Shapira, Berliner, and Melamed 2005) and immune function (Mehta, Yaffe, and Covinsky 2002; Sorkin, Rook, and Lu 2002), which are risk factors for cardiovascular disease (Whooley 2006) and other major health problems CITE.

Nevertheless, there are some mechanisms that may link both objective and subjective isolation to health outcomes in similar ways. Both objective social connectedness and perceived social connectedness can buffer the deleterious effects of stress exposure (Thoits 1995). Socially connected individuals, those who rarely experience loneliness, and those who perceive high levels of social support typically have more active coping strategies and greater self-esteem and sense of control (Cohen 1988; Cornman, Goldman, Glei, Weinstein, and Chang 2003; Ernst and Cacioppo 1999; Li and Ferraro 2005) – each of which can diminish the effects of stress (Pearlin 1989). And, the instrumental support provided by network members and co-residents may reduce stress by assisting in active coping (Waite and Hughes 1999).

Inflammation

Inflammation may be an important pathway through which psychosocial environments affect health.

C-reactive protein (CRP) is an immune protein and a non-specific marker of inflammation that is released as a part of the large systemic immune cascade response to infection or injury. CRP has been used as a marker of immune function and stress (McDade et al. 2004) and has been identified as an independent risk factor for cardiovascular disease (Smith et al. 2004). While C-reactive protein is correlated with other biological indicators of health, it is independently related to cardiovascular risk, even when accounting for age, smoking, blood pressure, and diabetes (Koenig et al. 1999; Pai et al. 2004; Ridker, 2003; Ridker et al. 1997; Ridker et al. 2002).

Chronic stress has been linked to elevated CRP concentrations (McDade, Hawkley, and

Cacioppo 2006), which is likely due to the fact that stress exposure leads to the increased

production of proinflammatory cytokines that incite CRP production (Dentino, Pieper, Rao,

Currie, Harris, Blazer, and Cohen 1999; Melamed, Shirom, Toker, Berliner, and Shapira 2004).

In turn, elevated CRP is associated with increased risk of cardiovascular disease (Danesh,

Whincup, Walker, Lennon, Thomson, Appleby, Gallimore, and Pepys 2000; Sesso, Buring,

Rifai, Blake, Gaziano, and Ridker 2003), diabetes (Thorand, Lowel, Schneider, Kolb, Meisinger,

Frohlich, and Koenig 2003) and cancer (Erlinger, Platz, Rifai, and Helzlsouer 2004), as well as

all-cause mortality among older adults (Dentino et al. 1999).

Hypothesis 1: Objective and subjective isolation are independently associated with
health among older adults.

Hypothesis 2a: Negative affective states mediate the relationship between objective
isolation and health.

Hypothesis 2b: Negative affective states mediate the relationship between subjective
isolation and health.

Hypothesis 3a: Health behaviors mediate the relationship between objective isolation and
health.

Hypothesis 3b: Health behaviors states mediate the relationship between subjective
isolation and health.

DATA AND METHODS

We use data from the National Social Life, Health, and Aging Project (NSHAP), a nationally representative population-based study of community-residing older adults. The NSHAP sample was selected from a multi-stage area probability design screened by the Institute for Social Research (ISR) for the Health and Retirement Study (HRS). The HRS design oversampled by race/ethnicity; NSHAP retained this design and also oversampled by age and gender. From summer 2005 to spring 2006, NSHAP interviewed 3,005 individuals, ages 57-85, achieving a final weighted response rate of 75.5 percent.

Most of the data for the NSHAP study were collected during a two-hour in-home interview. Following the in-person interview, respondents were given a paper-and-pencil questionnaire to complete at their leisure and return by mail. The return rate for the leave-behind questionnaire was 84 percent. The overall design of the NSHAP study was modularized, so that some questionnaire items were always included in the in-person questionnaire, while other items were included in either the in-person questionnaire or the leave-behind questionnaire for a randomly-selected subset of respondents.

Objective Social Isolation Scale

We use an *Objective Social Isolation Scale* based on eight items assessing respondents' lack of connectedness to other individuals and social groups, developed by York and Waite (York and Waite 2008). The scale has acceptable internal consistency, with a Chronbach's alpha of .73 and moderate to strong item-rest correlations. Two components – social network characteristics (eigenvalue = 2.75) and social participation (eigenvalue = 1.55) – account for about 54 percent of the variance

The eight variables are standardized, their values are averaged, and the computed scores are reversed so that they indicate objective isolation rather than connectedness. Scores on the objective social isolation scale range from -1.30 to 2.34, with a weighted mean of -.02 and standard deviation of .63. *Objective Social Isolation Scale* scores above zero indicate greater-than-average objective isolation, while scores below zero suggest lower-than-average isolation. In general, higher scores indicate greater objective social isolation.

Subjective Social Isolation Scale

Subjective isolation is measured using a scale combining nine items from NSHAP that indicate loneliness and perceived (lack of) social support. The *Subjective Social Isolation Scale* has acceptable internal consistency ($\alpha = .70$) and moderate to strong item-rest correlations. About 46 percent of the variance is comprised of two components: loneliness (eigenvalue = 2.02) and perceived social support (eigenvalue = 1.20).

The S*ubjective Social Isolation Scale* is constructed by standardizing each individual item and then averaging the scores. The scale ranges from -.98 to 3.63, with a weighted mean of -.01 and standard deviation of .59. Higher scores indicate greater subjective social isolation.

Dependent Variables

Blood Pressure

Two blood pressure measures are taken on the left arm using a Lifesource digital blood pressure monitor (Model: UA-767PVL). A third reading is taken if the first two readings differed by > 20 mmHg systolic or 14 mmHg diastolic. The measure of hypertension is coded 1= normal blood pressure if

2= prehypertensive if systolic bp >=??; 3=hypertensive if systolic by > 140??

Antihypertensive Drug Use

C-Reactive Protein

C-Reactive Protein (CRP) concentration was derived from finger-stick blood spots. CRP has often been collected through venipuncture, but new technologies for the less invasive collection of blood spots enabled NSHAP to assess CRP from capillary blood collected on filter paper. NSHAP field interviewers cleaned respondents' fingers with an alcohol swab and used sterile, single-use lancets to prick the respondents' fingers. Blood spots were dropped onto filter paper, allowed to dry, and shipped to the Laboratory for Human Biology at Northwestern University. The blood was extracted from the filter paper and a high-sensitivity enzyme-linked immunosorbent assay (ELISA) protocol, developed and validated for use with blood spots, was used to determine the blood-spot concentration of CRP in mg/L (McDade, Burhop, and Dohnal 2004).

NSHAP utilized a modularized design for the collection of biomeasures. A subset of 2,494 of the 3,005 respondents was randomly selected for finger-stick blood spot collection. About 87 percent or 2,105 of these respondents agreed to provide blood spots. Of those, 166 were not able to provide blood spots or the blood spots produced were not able to be analyzed.[1] In the end, 1,939 NSHAP respondents have valid data for CRP.

CRP concentrations in the NSHAP sample originally ranged from 0 to 100 mg/L. In order to examine CRP as an indicator of the kind of chronic, low-grade inflammation associated with chronic stress, we exclude cases in which extremely elevated CRP levels are suggestive of acute infection. According to guidelines provided by the American Heart Association and the

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[1] Some of the most common reasons for which blood spots were not analyzable include insufficient bleeding by the respondent or insufficient size of the blood spots placed on the filter paper (139 cases), shipping or lab tracking error (17 cases), and lancet malfunction (9 cases).

Centers for Disease Control and Prevention, blood-spot CRP concentrations higher than 8.6 mg/L are likely to represent acute inflammatory response rather than chronic stress exposure (McDade, Burhop, and Dohnal 2004). These high concentrations of CRP were found in 136 NSHAP respondents, or about 7 percent of cases with valid CRP concentrations. The proportion of respondents with evidence of acute inflammation is consistent with the proportions found in other samples of older adults (McDade, Hawkley, and Cacioppo 2006).

After discarding cases where CRP concentration exceeded 8.6 mg/L, we have a sample of ?? respondents with valid data on CRP concentrations. The distribution of CRP concentrations is right skewed, with a mean of 2.085 mg/L, median of 1.37 mg/L, and a standard deviation of 1.984 mg/L. To normalize the distribution, CRP concentrations are log-transformed prior to analysis.

Depression, Anxiety and Stress. *Depression:* Depressive symptomology was assessed using a modified version of the Center for Epidemiological Studies Depression Scale (CES-D) (Radloff 1977). In the United States, the CES-D is an effective and well-used measure of depressive symptomology for older adults (Lawton 1989), which has been used successfully in other studies of aging, including the Health and Retirement Study (Wallace and Herzog 1995). Subjects are asked to indicate on a four point scale how often in the past week they have felt in accordance with eleven different statements like "I could not get 'going'." Responses are summed for a total score which ranges from 0 to 33, with higher scores indicating more depressive symptomology. The standardized Cronbach's alpha was 0.80 (Shiovitz-Ezra, Leitsch, Graber, and Karraker 2007).

One item on the shortened CES-D asks whether respondents felt lonely during the past week, and loneliness is a component of the subjective social isolation scale. In order to decrease the overlap between these two scales, then, we remove the loneliness item from the CES-D scale.

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Following Cacioppo et al. (2006), we refer to this revised CES-D, minus the loneliness item, as the CES-D-ml. Removal of the loneliness item decreases the scale's internal consistency reliability only slightly (from $\alpha = .80$ to $\alpha = .78$). Scale scores range from 0 to 29, with higher scores indicating more depressive symptoms.

Anxiety is assessed using a modified version of the seven item anxiety subscale of the *Hospital Anxiety and Depression Scale* (HADS) in which respondents report on feelings of anxious mood, thoughts and restlessness over the past week (Zigmond & Snaith, 1983). Scores are summed and the resulting scale ranges from 0 to 21, with higher scores indicating more anxiety. The scale has a Cronbach's alpha of 0.76 (Shiovitz-Ezra, Leitsch, Graber, and Karraker 2007).

Stress is assessed using a 4-item modification of Cohen's Perceived Stress Scale (Cohen, 1983). PSS-4 score is obtained after reversing the two positive items and summing all items scores (total score is 0-12), with higher scores indicating a higher perceived stress level. The scale has a Cronbach's alpha of 0.72 (Shiovitz-Ezra, Leitsch, Graber, and Karraker 2007).

Health Behaviors

Obesity is assessed through direct measurement and interviewer ratings of respondent weight. Height and weight of respondents were measured directly during the in person interview. These are used to calculate BMI, which equals weight(kg)/[height(m)]^2 (World Health Organization 1995). However, ?? respondents could not be weighed for various reasons, mostly involving physical frailty. For these respondents, we use the interviewer's rating of the respondent's weight. Obesity is coded 1 if BMI greater than ??

Exercise. Respondents were asked: "Now I will be asking you about physical activities you may do on a regular basis. How often do you participate in physical activity such as walking, dancing, gardening, physical exercise or sports?" Regular exercise was coded 1 if ??

Smoking. Respondents were asked: "Do you smoke cigarettes now?" Those who

respondents said yes were coded as current smokers.

Alcohol Use. Next, we would like to know about your use of alcohol and tobacco… Do
you ever drink any alcoholic beverages such as beer, wine, or liquor? Have you ever drunk
alcohol? In the last three months, on average, how many days per week have you had any
alcohol to drink? (For example, beer, wine, or any drink containing liquor). In the last three
months, on the days you drink, about how many **drinks** do you have? In the last three months,
on how many **days** have you had four or more drinks in one occasion?

Sleep. Respondents were asked "Now let's talk about your sleeping habits…

How often do you feel really rested when you wake up in the morning?" Rested most is coded 1

if respondents said they felt rested most of the time.

Covariates

We include a number of sociodemographic variables as controls. These include respondent's

age, gender (1 = female), college attendance (1 = completed at least some college), race/

ethnicity (Black, Hispanic and Other) and co-residence with a marital or romantic partner (1 =

co-resident partner).

All covariates and dependent variables are summarized in Table 1.

Analytic Strategy

We use ordered logistic regression analysis to examine the effects of objective and subjective

isolation on hypertension. Ordered logistic regression is appropriate because of the ordinal nature

of the dependent variables. Both variables consist of *J* ordered categories, represented by the

integers 1, 2,…, *J*. Ordered logistic regression models the cumulative probability of giving a

response in category *j* or higher, as a linear function of the predictors. If β is the vector of

ordered-logit regression coefficients, then exp[β_K] is the odds ratio or the proportionate change in the odds of being above category j that is produced by a one-unit increase in χ_{ik}, the kth explanatory variable. One can interpret the coefficients in conventional terms; a positive regression coefficient means that an increase in the value of an independent variable is expected to raise a respondent's blood pressure. Coefficients can be used to assess statistical significance, but they are not directly interpretable. In the analysis of CRP, we use OLS regression to estimate the effects of objective and subjective isolation because log CRP is continuous. All regression models are survey-adjusted and weighted to account for probability of selection and non-response.

RESULTS

Individuals who are objectively isolated from others may feel lonely and perceive a lack of social support, but the correlation between objective and subjective isolation is only weak to moderate in strength ($r = .25, p < .001$). Therefore, lack of social connectedness is not always accompanied by feelings of loneliness and isolation. Conversely, loneliness and perceived lack of support can arise even among those who have frequent social interactions and a variety of social connections. Since objective and subjective isolation are conceptually distinct and are not strongly correlated, there is good reason to believe that they may be independently associated with health and that their relative importance may differ across various health outcomes.

CRP

DISCUSSION

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Table 1. Summary Statistics for Indicators Included in the Objective and Subjective Social Isolation Scales and Covariates

	Mean or Proportion[a]	Standard Deviation	n
Objective Social Isolation (Cronbach's alpha = .73)	**-.02**	**.63**	**3,005**
Social Network Characteristics			
Social network size {range = 0-5, 6 or more}	3.57	1.59	3,001
Social network range {number of types of relationships in the network; range = 0,5}	2.41	1.07	3,005
Proportion of social network members who live in the household {range = 0,1}	.29	.31	2,932
Average frequency of interaction with network members {range = 0,1 where 0 = the respondent does not contact any alters and 1 = respondent contacts all alters every day.}	.57	.26	2,931
Number of Friends			
"How many friends would you say you have?" {0 = "none", 1 = "1 friend," 2 = "2-3 friends," 3 = "4-9 friends," 4 = "10-20 friends," 5 = "more than 20."}	3.31	1.30	2,808
Social Participation			
Frequency of…			
Attending meetings of an organized group {from 1 = never to 7 = several times a week}	2.66	2.15	2,454
Socializing with friends and relatives {from 1 = never to 7 = several times a week}	4.39	1.30	2,472
Volunteering {from 1 = never to 7 = several times a week}	2.20	2.08	2,454
Subjective Social Isolation (Cronbach's alpha = .70)	**-.01**	**.59**	**2,939**
Loneliness			
How often do you... {1 = "hardly ever (or never)," 2 = "some of the time," 3 = "often"}			
Feel that you lack companionship?	1.41	.61	2,415
Feel left out?	1.32	.54	2,409
Feel isolated from others?	1.26	.51	2,416
Perceived Social Support			
How often can you… {1 = "often," 2 = "some of the time," 3 = "hardly ever (or never)"}			
Open up to members of your family?	1.68	.71	2,797
Rely on members of your family?	1.41	.65	2,793
Open up to your friends?	1.97	.73	2,704
Rely on your friends?	1.68	.71	2,860
Open up to your spouse or partner?	1.27	.54	2,012
Rely on your spouse or partner?	1.16	.45	2,007
Covariates and Dependent Variables			
Age (in decades)	6.80	.79	3,005
Attended college {1 = at least some college; 0 = no college attendance}	.51	.50	3,003
Co-morbidities {number of chronic conditions ever diagnosed, range = 0, 16}[b]	2.18	1.53	3,005
Depressive symptoms (CES-D-ml)	8.45	3.59	2,957
Female	.52	.50	3,005
Married or partnered	.73	.47	3,005
Non-white	.19	.46	2,993
Self-rated mental health[c]			
Poor	.02	--	53
Fair	.10	--	288
Good	.28	--	837
Very good	.37	--	1,098
Excellent	.24	--	719
Self-rated physical health[c]			
Poor	.07	--	224
Fair	.19	--	582
Good	.30	--	906
Very good	.31	--	921
Excellent	.12	--	360

[a] Survey-adjusted and weighted to account for the probability of selection, with post-stratification adjustments for non-response.

[b] Conditions included: 1) arthritis; 2) stomach or peptic ulcers; 3) emphysema, bronchitis, or lung disease; 4) asthma; 5) stroke, blood clot, or bleeding in the brain; 6) high blood pressure or hypertension; 7) diabetes or high blood sugar; 8) Alzheimer's disease or other form of dementia; 9) cirrhosis, or serious liver damage; 10) HIV/AIDS; 11) leukemia or polycythemia vera; 12) lymphoma; 13) skin cancer (including melanoma, basal cell carcinoma, and squamous cell carcinoma; 14) cancer, other than skin cancer, leukemia, or lymphoma; 15) poor kidney function; and 16) thyroid problems.

[c] Response proportions and frequencies presented are unweighted.

Table 2. OLS Regression of Mean Systolic Blood Pressure and Log-CRP on Objective Social Isolation, Subjective Social Isolation

	Dependent Variables					
	Mean Systolic Blood Pressure			Log-CRP		
	Model 1	Model 2	Model 3	Model 1	Model 2	Model 3
Co-resident Partner	-3.015**	-3.565**	-3.153**	-0.123	-0.089	-0.061
	(1.057)	(1.056)	(1.086)	(0.071)	(0.076)	(0.063)
Objective Social Isolation	0.766	1.265	1.299	0.106*	0.098	0.049
	(0.691)	(0.689)	(0.683)	(0.052)	(0.054)	(0.052)
Subjective Social Isolation	0.157	0.822	0.852	0.014	-0.018	0.002
	(0.705)	(0.876)	(0.860)	(0.060)	(0.070)	(0.071)
Systolic Blood Pressure				0.004**	0.004*	0.003*
				(0.002)	(0.002)	(0.002)
Hypertensivedrugs	1.307	1.109	1.216	0.097	0.108	0.024
	(0.819)	(0.881)	(0.920)	(0.062)	(0.066)	(0.064)
Depression		-0.186	-0.213*		0.022*	0.005
		(0.099)	(0.093)		(0.009)	(0.009)
Anxiety		0.059	0.042		-0.025*	-0.020*
		(0.178)	(0.189)		(0.010)	(0.010)
Stress		-0.189	-0.132		0.006	0.006
		(0.315)	(0.306)		(0.016)	(0.014)
Obesity			1.598			0.537**
			(0.887)			(0.090)
Exercise			0.665			-0.163**
			(0.810)			(0.048)
Smoking			0.937			0.357**
			(1.477)			(0.068)
Heavy Drink			5.454**			0.041
			(1.349)			(0.102)
Sleep			-0.240			-0.097
			(0.906)			(0.062)
Age	0.257**	0.308**	0.372**	-0.015**	-0.015**	-0.006
	(0.051)	(0.054)	(0.058)	(0.004)	(0.004)	(0.004)
Female	-2.452**	-2.401**	-1.274	0.208**	0.226**	0.258**
	(0.775)	(0.840)	(0.845)	(0.076)	(0.079)	(0.067)
Attend College	-1.326	-1.725*	-1.722*	-0.125*	-0.102	-0.076
	(0.756)	(0.800)	(0.788)	(0.060)	(0.056)	(0.051)
Black	4.151**	4.047**	4.219**	0.279**	0.297**	0.238*
	(1.412)	(1.447)	(1.512)	(0.090)	(0.087)	(0.091)
Hispanic, non-black	-3.085*	-3.469*	-3.440*	-0.109	-0.096	-0.052
	(1.525)	(1.634)	(1.630)	(0.083)	(0.087)	(0.084)
Others	-0.487	0.318	0.959	-0.120	-0.026	0.016
	(2.163)	(2.182)	(2.353)	(0.216)	(0.192)	(0.207)
Constant	121.816**	122.708**	115.319**	0.697	0.534	0.244
	(3.958)	(5.207)	(5.586)	(0.389)	(0.377)	(0.348)
Observations	2838	2622	2601	1730	1602	1591
R-squared	0.03	0.04	0.05	0.04	0.05	0.13

Standard errors in parentheses

* p< .05; ** p<.01

Table 3. OLS Regression of Mean Systolic Blood Pressure and Log-CRP on Objective Social Isolation,
    Loneliness, Lack of
Support

	Dependent Variables						
	Mean Systolic Blood Pressure				Log-CRP		
	Model 1	Model 2	Model 3		Model 1	Model 2	Model 3
Co-resident Partner	-4.529**	-4.562**	-4.156**		-0.097	-0.052	-0.017
	(1.176)	(1.181)	(1.194)		(0.081)	(0.083)	(0.069)
Objective Social Isolation	0.476	0.640	0.616		0.108	0.111	0.055
	(0.811)	(0.792)	(0.786)		(0.059)	(0.057)	(0.056)
Loneliness	-1.194**	-1.124*	-1.054*		0.013	-0.005	0.002
	(0.345)	(0.439)	(0.435)		(0.027)	(0.032)	(0.030)
Lack of Support	1.777*	1.758*	1.741*		0.017	-0.001	0.005
	(0.740)	(0.780)	(0.768)		(0.053)	(0.052)	(0.054)
Mean Systolic Blood Pressure					0.004*	0.004*	0.003
					(0.002)	(0.002)	(0.002)
Hypertensivedrugs	1.009	0.985	0.960		0.115	0.118	0.042
	(0.949)	(0.958)	(0.973)		(0.065)	(0.068)	(0.066)
Depression		-0.004	-0.052			0.021*	0.003
		(0.131)	(0.128)			(0.009)	(0.009)
Anxiety		-0.026	-0.051			-0.027*	-0.024*
		(0.192)	(0.203)			(0.011)	(0.011)
Stress		-0.042	0.013			0.012	0.015
		(0.291)	(0.284)			(0.017)	(0.016)
Obesity			1.703				0.504**
			(0.938)				(0.091)
Exercise			0.364				-0.150**
			(0.864)				(0.052)
Smoking			0.004				0.357**
			(1.587)				(0.088)
Drinks Heavily			5.009**				0.098
			(1.406)				(0.112)
Sleep			-0.652				-0.111
			(0.929)				(0.076)
Age	0.277**	0.294**	0.357**		-0.012**	-0.013**	-0.004
	(0.062)	(0.063)	(0.066)		(0.004)	(0.005)	(0.004)
Female	-2.734**	-2.611**	-1.571		0.278**	0.277**	0.305**
	(0.855)	(0.882)	(0.864)		(0.079)	(0.078)	(0.066)
Attend College	-2.043*	-2.234*	-2.277**		-0.114	-0.109	-0.088
	(0.800)	(0.849)	(0.848)		(0.065)	(0.062)	(0.059)
Black	3.931**	3.832*	4.111*		0.288**	0.300**	0.237*
	(1.430)	(1.527)	(1.630)		(0.097)	(0.095)	(0.091)
Hispanic, non-black	-3.503*	-3.679*	-3.688*		-0.040	-0.066	-0.018
	(1.683)	(1.747)	(1.758)		(0.088)	(0.096)	(0.096)
Others	0.594	1.022	1.508		-0.150	-0.090	-0.060
	(2.320)	(2.327)	(2.505)		(0.201)	(0.169)	(0.169)
Constant	126.864**	126.205**	120.071**		0.335	0.311	0.064
	(5.119)	(5.686)	(6.396)		(0.441)	(0.419)	(0.413)
Observations	2306	2232	2214		1440	1399	1388
R-squared	0.05	0.05	0.06		0.05	0.05	0.12

Standard errors in parentheses

Table 4. OLS Regression of Mean Systolic Blood Pressure and Log-CRP on Objective Social Isolation,
Quadratic Loneliness, Lack of Support

	Dependent Variables						
	Mean Systolic Blood Pressure				Log-CRP		
	Model 1	Model 2	Model 3		Model 1	Model 2	Model 3
Co-resident Partner	-4.565**	-4.621**	-4.229**		-0.099	-0.053	-0.020
	(1.183)	(1.193)	(1.204)		(0.080)	(0.082)	(0.069)
Objective Social Isolation	0.479	0.668	0.644		0.109	0.111	0.056
	(0.799)	(0.781)	(0.780)		(0.059)	(0.057)	(0.055)
Loneliness	-5.283**	-5.039**	-4.822**		-0.045	-0.032	-0.070
	(1.733)	(1.807)	(1.774)		(0.160)	(0.159)	(0.167)
Loneliness Squared	0.415*	0.400*	0.385*		0.006	0.003	0.007
	(0.172)	(0.180)	(0.176)		(0.015)	(0.015)	(0.016)
Lack of Support	1.733*	1.731*	1.714*		0.016	-0.002	0.003
	(0.754)	(0.797)	(0.785)		(0.054)	(0.052)	(0.055)
Systolic Blood Pressure					0.004*	0.004*	0.003
					(0.002)	(0.002)	(0.002)
Hypertensivedrugs	1.061	1.034	0.999		0.116	0.119	0.044
	(0.947)	(0.956)	(0.968)		(0.064)	(0.068)	(0.065)
Depression		-0.031	-0.081			0.021*	0.002
		(0.133)	(0.132)			(0.009)	(0.009)
Anxiety		-0.003	-0.029			-0.027*	-0.023*
		(0.191)	(0.202)			(0.011)	(0.011)
Stress		-0.059	-0.005			0.012	0.015
		(0.285)	(0.279)			(0.017)	(0.016)
Obesity			1.681				0.504**
			(0.929)				(0.091)
Exercise			0.334				-0.151**
			(0.859)				(0.052)
Smoking			-0.087				0.357**
			(1.591)				(0.088)
Heavy Drink			4.957**				0.098
			(1.386)				(0.112)
Sleep			-0.726				-0.113
			(0.926)				(0.077)
Age	0.279**	0.298**	0.359**		-0.012**	-0.013**	-0.004
	(0.062)	(0.064)	(0.066)		(0.004)	(0.004)	(0.004)
Female	-2.699**	-2.576**	-1.554		0.278**	0.277**	0.305**
	(0.848)	(0.878)	(0.865)		(0.078)	(0.078)	(0.066)
Attend College	-1.979*	-2.185*	-2.235*		-0.112	-0.108	-0.085
	(0.810)	(0.855)	(0.850)		(0.066)	(0.063)	(0.059)
Black	4.016**	3.936*	4.212*		0.290**	0.301**	0.239*
	(1.441)	(1.536)	(1.635)		(0.097)	(0.095)	(0.091)
Hispanic, non-black	-3.432*	-3.596*	-3.614*		-0.039	-0.065	-0.016
	(1.679)	(1.761)	(1.769)		(0.089)	(0.096)	(0.096)
Others	0.648	1.070	1.542		-0.151	-0.090	-0.062
	(2.377)	(2.393)	(2.574)		(0.201)	(0.170)	(0.172)
Constant	135.581**	134.686**	128.504**		0.463	0.368	0.229
	(5.820)	(6.544)	(6.926)		(0.617)	(0.580)	(0.620)
Observations	2306	2232	2214		1440	1399	1388
R-squared	0.05	0.05	0.06		0.05	0.05	0.12

Standard errors in parentheses