Short report

Loneliness and risk of mortality: A longitudinal investigation in Alameda County, California

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ABSTRACT

We investigated the prospective impact of self-reported loneliness on all-cause mortality, mortality from ischemic disease and mortality from other cardiovascular diseases. We tested these effects through GEE binomial regression models applied to longitudinal data from the Alameda County Study of persons aged 21 and over arranged into person-years. Controlling for age and gender, the chances of all-cause mortality were significantly higher among respondents reporting that they often feel lonely compared to those who report that they never feel lonely. Frequent loneliness was not significantly associated with mortality from ischemic heart disease but more than doubled the odds of mortality from other ailments of the circulatory system in models controlling for age and gender. Subsequent models showed that physical activity and depression may be important mediators of loneliness-mortality associations. Finally, we find support for the contention that chronic loneliness significantly increases risk of mortality but also find reason to believe that relatively recent changes in feelings of loneliness increase risk of mortality as well.

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Introduction

Loneliness is a common affliction in American society. Nationally representative surveys report that the percentage of Americans who regularly experience lonely feelings exceeds 25% (Perlman, 2004). The claim that loneliness is widespread in contemporary America should not come as a surprise upon noting that people nowadays appear to have fewer friends and family to confide in (McPherson, Smith-Lovin, & Brashears, 2006), the majority of marriages now end in divorce (Pinsof, 2002), and objectively-assessed social isolation appears to be on the rise with each generation (Putnam, 2000).

Numerous studies have documented associations between loneliness and health. For example, Steed, Boldy, Grenade, and Iredell (2007) reported a negative association between loneliness and self-rated health, Hawkley, Burleson, Berntson, and Cacioppo (2003) found that lonely people tend to have higher basal total peripheral resistance and lower cardiac output, Sorkin, Rook, and Lu (2002) determined that lonely people are more likely to suffer from an adverse coronary condition and Herlitz et al. (1998) found that lonely adults are less likely to recover successfully from cardiac surgery.

Several different explanations for the health effects of loneliness have been proposed in the literature. Some scholars suggest that the coping mechanisms used by people to deal with their loneliness can negatively affect their health. Lauder, Mummery, Jones, and Caperchione (2006) found that lonely people are more likely to smoke while Hawkley, Thisted, and Cacioppo (2009) discovered that they tend to exercise less. Loneliness has been linked to depression (Cacioppo, Hughes, Waite, Hawkley, & Thisted, 2006) and suicide (Conroy & Smith, 1983; Peck, 1983) and may be a risk factor for the sexual transmission of HIV (Muñoz-Laboy, Hirsch, & Quispe-Lazaro, 2009).

Hawkley and Cacioppo (2003, 2007) suggest that loneliness can also influence health by directly affecting bodily processes. For instance, they hypothesize that loneliness compromises the body's rejuvenating functions by disturbing sleep or otherwise hindering sleep's recuperative effect. They also argue that loneliness is a subtle but long-lasting stressor which creates wear and tear on the body similar to the effects of aging. From the latter hypothesis emerges a picture of lonely young adults who show signs of subclinical disease processes that persist across the years and manifest in ill health in midlife and beyond where they are especially vulnerable to high blood pressure and cardiac dysfunction (Hawkley, Masi, Berry, & Cacioppo, 2006). Thurston and Kubzansky (2009) recently reported a prospective association between loneliness and coronary heart disease among women that appears to support the wear and tear hypothesis.

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We used longitudinal survey data from a sample of adults aged 21 and older in the Alameda County Study to investigate the relationship between loneliness and mortality in light of the above-mentioned explanations. Although numerous studies have identified empirical associations between loneliness and health, few of these have used longitudinal data and thus little is certain about the persistence of loneliness over time, its long-term wear on the body and its eventual effect on mortality. Moreover, although some of the outcomes of loneliness, such as suicide and HIV infection, are believed to affect younger adults more than older adults (Brannon & Feist, 2007), the literature on loneliness and health has to date predominantly focused on elderly people.

Data

The Alameda County Health and Ways of Living Study (Berkman & Breslow, 1983) included a stratified longitudinal survey collected in five waves between 1965 and 1999. After dividing Alameda County into homogeneous geographic units, a mailed survey was deployed in 1965 on a representative sample that included the 8083 members of 4452 non-institutionalized households who were 21 years of age or older, or were 20 years old and married, in 1965. The overall response rate in the first wave was 85.7% ($n = 6928$). Subsequent waves were administered to survivors in 1974, 1994, 1995 and 1999, although the questionnaire administered in 1995 was an abbreviated version of the longer ones used in the other waves. Year of death was recorded for the deceased when known and cause of death was ascertained from ICD-9 codes listed on death certificates. In our analyses we distinguished between mortality from all causes, mortality from ischemic heart disease and mortality from other cardiovascular diseases.

We restricted our analyses to respondents who were 21 years of age or older in 1965 ($n = 6789$). Of these people, information including year of death if deceased was available for 5454 respondents in 1974 (80.3% of the sample), 4808 respondents in 1994 (70.8%), 4718 respondents in 1995 (69.5%) and 4522 respondents in 1999 (66.6%). In total, 3168 of the 6789 respondents (46.7%) were known to have died by the end of the study.

Loneliness

Perlman and Peplau (1981) define loneliness as "the unpleasant experience that occurs when a person's network of social relations is deficient in some important way, either quantitatively or qualitatively" (p. 31). More recently, loneliness researchers have understood loneliness to be a subjective perception of social isolation which may or may not be closely associated with objective characteristics of social circumstances (Cacioppo & Hawkley, 2009; Cornwell & Waite, 2010). We utilized a survey question which asked respondents how often they feel 'very lonely or remote from other people' to measure loneliness. Response categories for this question were 'never,' 'sometimes' and 'often.' Table 1 indicates that approximately half of the respondents in each wave reported being 'never' lonely and that very few respondents claimed to be 'often' lonely at any one time.

Table 1
Characteristics of the survey sample.

	1965	(%)	1974	(%)	1994	(%)	1995	(%)	1999	(%)
Loneliness I										
Never lonely	3460	51.6%	2198	46.6%	1358	50.9%	1332	52.9%	1130	54.2%
Sometimes lonely	2902	43.3%	2193	46.5%	1187	44.5%	1081	42.9%	873	41.9%
Often lonely	344	5.1%	328	7.0%	125	4.7%	104	4.1%	82	3.9%
Loneliness II										
Consistently never lonely	–	–	1404	32.8%	711	29.3%	891	38.7%	765	40.8%
Consistently sometimes lonely	–	–	1188	27.8%	667	27.5%	691	30.0%	521	27.8%
Consistently often lonely	–	–	60	1.4%	28	1.2%	36	1.6%	20	1.1%
From often to sometimes lonely	–	–	106	2.5%	111	4.6%	58	2.5%	37	2.0%
From sometimes to never lonely	–	–	530	12.4%	473	19.5%	298	12.9%	237	12.7%
From often to never lonely	–	–	43	1.0%	32	1.3%	14	0.6%	13	0.7%
From never to sometimes lonely	–	–	716	16.7%	315	13.0%	253	11.0%	228	12.2%
From sometimes to often lonely	–	–	152	3.6%	58	2.4%	48	2.1%	38	2.0%
From never to often lonely	–	–	76	1.8%	28	1.2%	14	0.6%	14	0.7%
Gender										
Female	3679	54.2%	2674	55.6%	1538	56.9%	1433	56.6%	1183	56.4%
Male	3110	45.8%	2133	44.4%	1167	43.1%	1099	43.4%	916	43.6%
Race										
White	5351	78.8%	3868	80.5%	2221	82.1%	2097	82.8%	1766	84.1%
Black	851	12.5%	486	10.1%	236	8.7%	209	8.3%	150	7.1%
Other non-White	585	8.6%	453	9.4%	248	9.2%	226	8.9%	183	8.7%
Marital status										
Married	5070	25.3%	3591	25.1%	1862	69.1%	–	–	1425	68.0%
Unmarried	1719	74.7%	1206	74.9%	834	30.9%	–	–	670	32.0%
Smoking										
Never smoked	2667	39.7%	2001	41.6%	1196	44.5%	–	–	955	46.0%
Past smoker	1073	16.0%	1161	24.2%	1106	41.1%	–	–	914	44.0%
Current smoker	2985	44.4%	1616	33.6%	387	14.4%	–	–	207	10.0%
Trouble sleeping										
Almost never	3583	52.9%	2354	49.0%	1195	44.2%	1098	43.5%	861	41.1%
Sometimes	2649	39.1%	1936	40.3%	1173	43.4%	1082	42.8%	936	44.6%
Often	544	8.0%	2354	10.4%	333	12.3%	346	13.7%	300	14.3%
Depression										
Never	2365	35.3%	1555	33.3%	1214	46.4%	1151	46.2%	1017	49.5%
Sometimes	4009	59.8%	2837	60.8%	1294	49.5%	1233	49.4%	961	46.8%
Often	332	5.0%	272	5.8%	107	4.1%	110	4.4%	77	3.7%
Total cases	6789		4807		2705		2532		2099	

Because we are interested in determining whether chronic loneliness is especially relevant for mortality outcomes as hypothesized by Hawkley and Cacioppo (2003, 2007), we constructed a second loneliness variable that assessed changes in loneliness between the current or most recent wave and the wave that preceded it. Levels of loneliness that remained stable over time were coded as: consistently 'often' lonely, consistently 'sometimes' lonely, or consistently 'never' lonely. Other categories characterized movement from 'never' to 'sometimes' lonely, from 'never' to 'often' lonely, from 'sometimes' to 'often' lonely, from 'often' to 'never' lonely, from 'sometimes' to 'never' lonely, and from 'often' to 'sometimes' lonely. Table 1 indicates that more than 30% of respondents were consistently 'never' lonely at any one time, that less than 2% of respondents were consistently 'often' lonely at any one time, and that there was a substantial amount of movement between loneliness scores for respondents from one wave to another.

Socio-demographic characteristics

Gender (coded male/female) and race (coded White/Black/Other) were first recorded in 1965. Respondents were asked about their marital status (coded married/unmarried) and household incomes in 1965, 1974, 1994 and 1999 and their years of education in 1965, 1974 and 1994. Education was capped at 17 years of schooling in each wave in order to make the education measures consistent. The response categories for income changed significantly across the waves, so we created continuous variables that replaced the ordinal values with the median incomes for the categories. Median incomes for the upper open-ended categories were extrapolated by assuming that the logged incomes followed a normal curve, resulting in upper-end median values of $35,000 in 1965, $45,000 in 1974, $230,000 in 1994 and $217,500 in 1999. The resulting variables were then adjusted for inflation and transformed by taking the natural log.

Other variables

Two questions asked respondents how many relatives and how many friends they have that they 'feel close to.' These were four-level ordinal measures in 1965 but were continuous up to a value representing 10 or more in later waves. We replaced the 1965 ordinal

values with the median values for the respective ranges and capped the new variables at 10, the minimum value of the highest range. We used self-reported participation in physical exercise, sports and either swimming or long walks combined in a single continuous measure to measure physical activity (following Strawbridge, Deleger, Roberts, & Kaplan, 2002). A variable distinguished current smokers, past smokers and respondents who had never smoked while another determined whether respondents had trouble either getting to sleep or staying asleep. Finally, we included a survey question to measure depression that asked respondents how often they felt 'sad or very unhappy,' with 'never', 'sometimes' and 'often' as response options. Table 1 contains the distributions of responses to the categorical variables used in our analyses.

Methods

We accomplished our investigation in two stages. First, we created a series of cumulative binomial regression models to predict all-cause mortality, mortality from ischemic heart disease and mortality from other cardiovascular diseases with the original loneliness variable. The first model for each dependent variable included loneliness, age and gender, the second added race, education and income, the third added marital status and close relationships with friends and family, the fourth added physical activity, smoking and trouble sleeping, and the fifth added depression. These sets of cumulative models, described in Tables 2 and 3, enabled us to determine the direction and strength of the effects of loneliness on mortality controlling for potential causes of spuriousness − for example, close relationships are known to influence both loneliness (Hawkley et al., 2008) and mortality (Berkman & Syme, 1979) − and then the degree to which the loneliness effects may be mediated by health behaviors and by feelings of depression.

In the second stage of our investigation we replicated these sets of models on the sample of survey respondents who were known to have survived until at least 1974, substituting the second version of the loneliness variable for the original version. These models, described in Table 4, enabled us to investigate the degree to which chronic versus transient experiences of loneliness (Young, 1982) were responsible for mortality outcomes.

We used Generalized Estimating Equations (GEE) applied to a person-years version of the survey dataset to produce the

Table 2
Binomial regression models predicting all-cause mortality ($n = 76{,}137$ person years; total deaths $= 887$).

	Model 1		Model 2		Model 3		Model 4		Model 5	
	OR	[95% CI]	OR	[95% CI]	OR	[95% CI}	OR	[95% CI]	OR	[95% CI]
Sometimes lonely	1.20**	[1.05–1.38]	1.18*	[1.03–1.35]	1.13	[0.98–1.31]	1.11	[0.96–1.29]	1.01	[0.86–1.17]
Often lonely	1.63***	[1.25–2.13]	1.50**	[1.14–1.98]	1.39*	[1.05–1.83]	1.22	[0.93–1.60]	1.03	[0.76–1.39]
Age	1.09***	[1.09–1.10]	1.09***	[1.08–1.09]	1.08***	[1.08–1.09]	1.09***	[1.08–1.10]	1.09***	[1.08–1.10]
Gender	1.39***	[1.22–1.59]	1.46***	[1.27–1.68]	1.52***	[1.32–1.76]	1.56***	[1.34–1.81]	1.59***	[1.36–1.85]
Race = Black			1.06	[0.83–1.35]	1.04	[0.82–1.32]	1.07	[0.85–1.36]	1.08	[0.85–1.36]
Race = other non-white			1.01	[0.77–1.31]	0.99	[0.76–1.29]	1.04	[0.79–1.37]	1.06	[0.81–1.39]
Education			0.97**	[0.95–0.99]	0.97**	[0.95–0.99]	0.99	[0.98–1.02]	1.00	[0.98–1.02]
Income			0.85***	[0.78–0.93]	0.88**	[0.81–0.97]	0.92	[0.84–1.00]	0.92	[0.84–1.00]
Married status					0.84*	[0.71–0.99]	0.86	[0.73–1.02]	0.86	[0.73–1.01]
Number of close friends					0.99	[0.96–1.01]	0.99	[0.97–1.02]	1.00	[0.97–1.02]
Number of close relatives					0.98	[0.96–1.01]	0.99	[0.97–1.02]	0.99	[0.97–1.02]
Physical activity							0.80***	[0.76–0.85]	0.81***	[0.76–0.85]
Current smoker							2.06***	[1.73–2.45]	2.04***	[1.71–2.42]
Past smoker							1.21*	[1.02–1.44]	1.20*	[1.01–1.42]
Trouble sleeping = sometimes							0.99	[0.85–1.14]	0.96	[0.83–1.12]
Trouble sleeping = often							1.17	[0.95–1.45]	1.12	[0.91–1.38]
Sometimes depressed									1.27**	[1.09–1.49]
Often depressed									1.41*	[1.03–1.93]

***$p < 0.001$, **$p < 0.01$, *$p < 0.05$.

Table 3
Binomial regression models predicting death from cardiovascular diseases (n = 76,137 person-years).

	Model 1		Model 2		Model 3		Model 4		Model 5	
	OR	[95% CI]	OR	[95% CI]	OR	[95% CI]	OR	[95% CI]	OR	[95% CI]
Ischemic heart disease (212 deaths)										
Sometimes lonely	1.07	[0.81–1.42]	1.04	[0.78–1.37]	1.05	[0.79–1.40]	1.04	[0.77–1.39]	1.00	[0.72–1.39]
Often lonely	1.22	[0.69–2.19]	1.07	[0.60–1.91]	1.09	[0.61–1.97]	0.96	[0.53–1.72]	0.77	[0.37–1.60]
Age	1.09***	[1.08–1.10]	1.09***	[1.07–1.10]	1.09***	[1.07–1.10]	1.10***	[1.08–1.11]	1.10***	[1.08–1.11]
Gender	1.83***	[1.40–2.41]	1.96***	[1.49–2.60]	1.91***	[1.43–2.54]	1.92***	[1.43–2.58]	1.95***	[1.45–2.62]
Race = Black			0.89	[0.54–1.45]	0.90	[0.55–1.47]	0.95	[0.59–1.55]	0.96	[0.59–1.56]
Race = Other non-white			1.07	[0.65–1.76]	1.09	[0.66–1.78]	1.16	[0.70–1.90]	1.16	[0.70–1.90]
Education			0.96*	[0.92–1.00]	0.96*	[0.92–0.99]	0.99	[0.95–1.02]	0.99	[0.95–1.02]
Income			0.79**	[0.67–0.93]	0.78**	[0.66–0.93]	0.82*	[0.69–0.97]	0.82*	[0.69–0.98]
Married					1.08	[0.77–1.51]	1.12	[0.80–1.57]	1.11	[0.79–1.56]
Number of close friends					1.02	[0.97–1.07]	1.03	[0.98–1.08]	1.03	[0.98–1.08]
Number of close relatives					0.98	[0.94–1.03]	0.99	[0.95–1.04]	0.99	[0.95–1.04]
Exercise							0.79***	[0.71–0.88]	0.79***	[0.71–0.89]
Current smoker							2.66***	[1.88–3.77]	2.63***	[1.86–3.73]
Past smoker							1.24	[0.87–1.76]	1.22	[0.86–1.74]
Trouble sleeping = sometimes							0.93	[0.68–1.28]	0.92	[0.68–1.27]
Trouble sleeping = often							1.28	[0.85–1.93]	1.23	[0.81–1.86]
Sometimes depressed									1.06	[0.76–1.48]
Often depressed									1.59	[0.81–3.12]
Other cardiovascular diseases (220 deaths)										
Sometimes lonely	1.23	[0.93–1.63]	1.20	[0.91–1.58]	1.12	[0.84–1.49]	1.10	[0.82–1.47]	0.89	[0.65–1.21]
Often lonely	2.30***	[1.46–3.64]	2.02**	[1.26–3.25]	1.77*	[1.10–2.86]	1.55	[0.96–2.49]	1.10	[0.65–1.85]
Age	1.11***	[1.10–1.12]	1.10***	[1.09–1.12]	1.10***	[1.08–1.11]	1.10***	[1.09–1.12]	1.10***	[1.09–1.12]
Gender	0.95	[0.73–1.25]	1.00	[0.76–1.32]	1.15	[0.85–1.55]	1.29	[0.93–1.78]	1.34	[0.96–1.86]
Race = Black			1.15	[0.76–1.76]	1.11	[0.73–1.67]	1.14	[0.76–1.73]	1.16	[0.77–1.74]
Race = other non-white			0.83	[0.47–1.46]	0.79	[0.45–1.41]	0.84	[0.47–1.48]	0.87	[0.49–1.54]
Education			0.94**	[0.91–0.99]	0.94**	[0.90–0.98]	0.96	[0.92–1.01]	0.97	[0.93–1.01]
Income			0.83*	[0.70–1.00]	0.90	[0.76–1.08]	0.93	[0.78–1.12]	0.93	[0.78–1.11]
Married					0.62**	[0.45–0.87]	0.65*	[0.47–0.91]	0.64*	[0.46–0.90]
Number of close friends					0.98	[0.93–1.03]	0.99	[0.94–1.04]	0.99	[0.95–1.04]
Number of close relatives					0.98	[0.94–1.03]	0.99	[0.94–1.03]	0.99	[0.94–1.03]
Exercise							0.79***	[0.70–0.88]	0.79***	[0.71–0.89]
Current smoker							1.57*	[1.11–2.22]	1.53*	[1.08–2.17]
Past smoker							0.88	[0.62–1.25]	0.87	[0.62–1.23]
Trouble sleeping = sometimes							0.90	[0.66–1.22]	0.86	[0.63–1.17]
Trouble sleeping = often							1.36	[0.93–1.99]	1.25	[0.86–1.83]
Sometimes depressed									1.68**	[1.22–2.30]
Often depressed									1.97*	[1.11–3.49]

***p < 0.001, **p < 0.01, *p < 0.05.

binomial regression models. We used unstructured working correlation matrices but found similar results with AR-1 and exchangeable correlation matrices. Results were also similar to those obtained by using discrete-time hazard models with the logit link and age as the measure of time. To create person-years we created a row in the dataset for each year that a given respondent was known to be alive and a variable that indicated whether the respondent had died in a given year. Each row contained the information provided by the respondent in the most recent wave of the survey. For respondents who died during the course of the study, the final row represented the year in which they had died. For respondents who survived and did not attrite from the study, the last row represented 2000, the final year in which mortality data were collected. Gender and race were assumed to remain constant across the lifespan but age was updated for each person-year.

A strategy of list-wise deletion applied to the binomial regression models produced N = 6079 in Wave 1, a loss of 710 cases overall (10.5% of the sample). The biggest contributors to missing data in Wave 1 were income (n = 358) and the physical activity index (n = 129). Sample attrition was unrelated to loneliness (results not shown). The majority of the independent variables in our models were subject to change over time, and the lengthy gaps between the first and second waves and second and third waves of the study were particularly problematic in this regard. To resolve this issue, we removed all of the person-years that exceeded 5 years from the most recent wave of the survey from our dataset, leaving us with 887 deaths to explain in stage one of our analyses and 566 deaths to explain in stage two.

Results

Regarding all-cause mortality, Model 1 in Table 2 indicates that the odds of dying for people who reported being 'often' lonely were 1.63 times as high as those for people who reported being 'never' lonely, controlling for age and gender. Being 'sometimes' lonely had a weaker but still statistically significant effect on mortality. The effect of frequent loneliness diminished as socio-demographic characteristics, marital status and close relationships were added to the models and lost statistical significance with the introduction of physical activity, smoking and trouble sleeping. Supplementary analyses (not shown) indicated that physical activity and to a lesser extent smoking were mainly responsible for the reduced effect of loneliness from Model 3 to Model 4. Upon controlling for depression the remaining effect of loneliness on mortality was negligible.

The models in Table 3 describe the effects of loneliness on mortality from ischemic heart disease and on mortality from other cardiovascular diseases. Loneliness did not display a statistically significant effect on mortality from ischemic heart disease. The effect of loneliness on mortality from other cardiovascular diseases

Table 4
Binomial regression models predicting all-cause mortality ($n = 40,108$ person years; total deaths $= 566$).

	Model 1		Model 2		Model 3		Model 4		Model 5	
	OR	[95% CI]	OR	[95% CI]	OR	[95% CI]	OR	[95% CI]	OR	[95% CI]
Consistently sometimes lonely	1.09	[0.88–1.36]	1.07	[0.86–1.33]	1.01	[0.81–1.26]	0.97	[0.77–1.21]	0.82	[0.64–1.04]
Consistently often lonely	1.71	[0.89–3.28]	1.44	[0.73–2.86]	1.29	[0.64–2.58]	1.10	[0.55–2.19]	0.85	[0.42–1.72]
From often to sometimes lonely	2.03***	[1.34–3.08]	1.86**	[1.22–2.83]	1.71*	[1.12–2.62]	1.52	[0.96–2.41]	1.27	[0.80–2.02]
From sometimes to never lonely	0.81	[0.60–1.08]	0.79	[0.59–1.05]	0.77	[0.58–1.03]	0.74*	[0.55–1.00]	0.70*	[0.52–0.95]
From often to never lonely	2.24	[0.98–5.12]	1.98	[0.86–4.59]	1.90	[0.83–4.36]	1.69	[0.72–3.95]	1.65	[0.72–3.79]
From never to sometimes lonely	1.21	[0.94–1.55]	1.16	[0.90–1.49]	1.12	[0.87–1.45]	1.12	[0.86–1.44]	0.97	[0.75–1.27]
From sometimes to often lonely	1.30	[0.77–2.20]	1.19	[0.70–2.01]	1.12	[0.66–1.87]	1.02	[0.62–1.65]	0.78	[0.46–1.31]
From never to often lonely	1.85*	[1.09–3.16]	1.66	[0.98–2.83]	1.57	[0.93–2.67]	1.28	[0.76–2.15]	1.01	[0.60–1.70]
Age	1.10***	[1.09–1.10]	1.09***	[1.08–1.10]	1.09***	[1.08–1.10]	1.09***	[1.08–1.10]	1.09***	[1.08–1.10]
Gender	1.35***	[1.14–1.60]	1.47***	[1.23–1.74]	1.50***	[1.25–1.81]	1.57***	[1.30–1.90]	1.60***	[1.32–1.93]
Race = Black			0.88	[0.64–1.20]	0.86	[0.62–1.17]	0.89	[0.66–1.21]	0.89	[0.65–1.20]
Race = other non-white			0.98	[0.70–1.36]	0.95	[0.68–1.32]	1.02	[0.73–1.42]	1.04	[0.75–1.44]
Education			0.98	[0.96–1.01]	0.98	[0.95–1.01]	1.01	[0.98–1.03]	1.01	[0.98–1.04]
Income			0.79***	[0.70–0.88]	0.80***	[0.71–0.90]	0.85**	[0.76–0.96]	0.85**	[0.76–0.96]
Married status					0.90	[0.73–1.11]	0.92	[0.75–1.14]	0.92	[0.75–1.13]
Number of close friends					0.98	[0.95–1.01]	0.99	[0.96–1.02]	0.99	[0.96–1.02]
Number of close relatives					0.99	[0.96–1.02]	1.00	[0.97–1.02]	1.00	[0.97–1.03]
Physical activity							0.79***	[0.74–0.84]	0.79***	[0.74–0.85]
Current smoker							1.87***	[1.49–2.35]	1.85***	[1.47–2.33]
Past smoker							1.18	[0.96–1.45]	1.17	[0.96–1.44]
Trouble sleeping = sometimes							1.02	[0.85–1.23]	0.99	[0.82–1.20]
Trouble sleeping = often							1.14	[0.87–1.48]	1.06	[0.82–1.39]
Sometimes depressed									1.40***	[1.15–1.70]
Often depressed									1.62*	[1.12–2.36]

***$p < 0.001$, **$p < 0.01$, *$p < 0.05$.

closely resembled the nature of its effect on all-cause mortality but was even stronger in magnitude. The loneliness effect on this form of mortality diminished in strength but remained statistically significant after controlling for socio-demographic characteristics and social circumstances and then lost significance after additionally controlling for health behaviors and depression.

As shown in Table 4, respondents who felt consistently 'often' lonely were at higher risk of mortality than respondents who felt consistently 'never' lonely, controlling for age and gender, although the difference was not statistically significant. Respondents who felt 'often' lonely in the more distant past but subsequently felt less lonely incurred the highest risk of mortality, followed by respondents who shifted from 'never' to 'often' lonely, and respondents who shifted from 'sometimes' to 'never' lonely incurred the lowest risks of mortality. Results for mortality from ischemic heart disease and from other circulatory diseases (not shown) were inconclusive, possibly due to small numbers of cause-specific deaths.

In summary, loneliness manifested an association with all-cause mortality that persisted after controlling for potential causes of spuriousness and then was attenuated after controlling for health behaviors and depression. Loneliness was not related to mortality from ischemic heart disease but manifested an association with mortality from other cardiovascular diseases that persisted after controlling for potential causes of spuriousness and social circumstances and then was attenuated after controlling for health behaviors and depression. Finally, changes in loneliness from one wave to another were a risk factor for mortality, even among people who felt substantially less lonely than they had previously.

Discussion

Our study has several important limitations. First, all of the data are self-reported. Second, we used an imprecise measure of loneliness that has only three response categories, conflates loneliness and remoteness from others and potentially conflates intensity of loneliness and frequency of loneliness, leading to obvious issues of validity and reliability. A third limitation pertains to the irregular

intervals at which the data were collected, one gap fully 20 years in length, an issue that we could only imperfectly resolve analytically by removing person-years containing information older than 5 years. Finally, associations with theoretically important causes of death other than those involving the cardiovascular system could not be adequately investigated here because of sample size limitations. For example, there were only 15 suicide deaths and 7 deaths from infectious diseases in the sample.

In GEE binomial regression models predicting all-cause mortality, the odds of dying were about 40% higher among people who claimed to often feel lonely than among those who never feel lonely, net of socio-demographic influences and social relationships. The effect of loneliness on mortality from other cardiovascular diseases such as stroke and cardiac arrest was even greater. Among the first empirical demonstrations of a loneliness effect on mortality using representative, longitudinal data, our study indicates that loneliness is an important health risk. In our models, health behaviors, especially physical activity, and depression appeared to explain the effects of loneliness on all-cause mortality and on mortality from some cardiovascular diseases, suggesting that they may be important mediators of the loneliness effect on mortality.

Other provocative results came from our models testing the effects of chronic versus transient experiences of loneliness on mortality. We found that the greatest risks of mortality were associated not with subjective perceptions of loneliness that were stable over time but with perceptions of loneliness that were more volatile, especially for people who felt lonely in the past but subsequently *recovered* to some extent. This finding lends some support to the wear and tear hypothesis proffered by Hawkley and Cacioppo (2003, 2007) given that the detrimental effects of loneliness appear to have had a long trajectory for these respondents. However, these findings also suggest that the detrimental effects of loneliness may be more imminent than previous literatures have assumed and that changing fortunes in loneliness may be particularly detrimental for health and well-being.

As this is one of very few longitudinal studies of the health effects of loneliness on a representative sample, more work is needed to distinguish the effects of loneliness from mediating

health behaviors and possible confounders as they relate to mortality and morbidity. It is possible that loneliness characterizes a kind of sadness for some people and that this affect is common to both loneliness and depression. Future health research should therefore consider loneliness and depression in tandem and distinguish between them more clearly than we could do here.

Our findings suggest that loneliness is a health concern for people of all ages. Baumeister and Leary (1995) argue that human beings are fundamentally motivated by a need for belonging in personal communities. People who do not seem to meet this fundamental need suffer accordingly in terms of their physical health as well as their overall well-being. If the search for belonging is so intimately woven into the human character, and if loneliness is reflective of a failure to find satisfaction in ways that can prove fatal, then our study has important implications for public health, especially if the trend towards greater social isolation in North America continues.

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