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Title

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Permalink

Journal

ISSN

Authors

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Publication Date

DOI

Peer reviewed

High prevalence and adverse health effects of loneliness in community-dwelling adults across the lifespan: role of wisdom as a protective factor

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ABSTRACT

Objectives: This study of loneliness across adult lifespan examined its associations with sociodemographics, mental health (positive and negative psychological states and traits), subjective cognitive complaints, and physical functioning.

Design: Analysis of cross-sectional data

Participants: 340 community-dwelling adults in San Diego, California, mean age 62 (SD = 18) years, range 27–101 years, who participated in three community-based studies.

Measurements: Loneliness measures included UCLA Loneliness Scale Version 3 (UCLA-3), 4-item Patient-Reported Outcomes Measurement Information System (PROMIS) Social Isolation Scale, and a single-item measure from the Center for Epidemiologic Studies Depression (CESD) scale. Other measures included the San Diego Wisdom Scale (SD-WISE) and Medical Outcomes Survey- Short form 36.

Results: Seventy-six percent of subjects had moderate-high levels of loneliness on UCLA-3, using standardized cut-points. Loneliness was correlated with worse mental health and inversely with positive psychological states/traits. Even moderate severity of loneliness was associated with worse mental and physical functioning. Loneliness severity and age had a complex relationship, with increased loneliness in the late-20s, mid-50s, and late-80s. There were no sex differences in loneliness prevalence, severity, and age relationships. The best-fit multiple regression model accounted for 45% of the variance in UCLA-3 scores, and three factors emerged with small-medium effect sizes: wisdom, living alone and mental well-being.

Conclusions: The alarmingly high prevalence of loneliness and its association with worse health-related measures underscore major challenges for society. The non-linear age-loneliness severity relationship deserves further study. The strong negative association of wisdom with loneliness highlights the potentially critical role of wisdom as a target for psychosocial/behavioral interventions to reduce loneliness. Building a wiser society may help us develop a more connected, less lonely, and happier society.

Key words: aging, gender differences, resilience, depression, anxiety

Introduction

Loneliness has been considered the latest global health epidemic, with serious health implications. According to Vivek Murthy, the former US Surgeon General, the reduction in life span associated with loneliness is similar to that caused by smoking 15

cigarettes a day, and is greater than that due to obesity (McGregor, 2017). The UK government recently established a Ministry of Loneliness to address psychosocial and health needs of lonely people. Issues regarding loneliness have also drawn attention of the private sector, as shown by a recent study exploring how businesses and governments can partner to address loneliness in the aging population (Myers and Palmarini, 2017). In China, loneliness levels in older adults increased from 1995 to 2011 by more than one standard deviation (Yan *et al.*, 2014).

Loneliness has been linked to poor mental health [e.g., depression, hopelessness, substance use, and cognitive impairment], as well as worse physical health [e.g., malnutrition, worse motor function, hypertension, disrupted sleep, frailty], and higher mortality (Aanes *et al.*, 2011; Boss *et al.*, 2015; Cacioppo *et al.*, 2002; Tabue Teguo *et al.*, 2016; Yu *et al.*, 2016). Biological mechanisms such as dysregulated hypothalamic-pituitary-adrenal axis function and dysregulated immune function have been proposed to mediate the link between loneliness and these poor health outcomes (Cacioppo *et al.*, 2002; van Beljouw *et al.*, 2014).

Loneliness is defined as distress resulting from a discrepancy between actual and desired social relationships (Hawkley and Cacioppo, 2010). Loneliness may be considered a personality trait associated with negative states (anxiety, depression) and negative traits (lower levels of optimism and resilience) (Ben-Zur, 2012; Zebhauser *et al.*, 2014). Most personality traits are relatively stable with roughly 35%–50% heritability, though they are also modifiable. According to van Roekel *et al.* (2016), loneliness may have both trait and state characteristics; however, persistence of loneliness can lead to negative health consequences. Loneliness is distinct from living alone, solitude, and social isolation; though they may be interrelated. Reported psychosocial risk factors for loneliness include having few close relationships, being single (widowed, divorced, or never married), worsening physical health, and lower socioeconomic status (Cohen-Mansfield *et al.*, 2016; Jakobsson and Hallberg, 2005); all of these factors may increase social isolation (Fung *et al.*, in press; Palmer *et al.*, in press).

The reported prevalence of loneliness in the US ranges from 17% to 57% in the general population and is higher in people with physical and mental illnesses including heart disease, depression, anxiety, and dementia (Musich *et al.*, 2015). The differing prevalence rates may be related to varied definitions of loneliness, differences in loneliness measures used, and specific subpopulation studied.

Relationships of loneliness severity with age and sex are not clear. Studies have reported increased loneliness during adolescence (Rokach, 2000),

middle age (Luhmann and Hawkley, 2016; Wilson and Moulton, 2010), and older age (Ernst and Cacioppo, 1999; Fees *et al.*, 1999; Jylha, 2004). The relationship between loneliness and age is confounded by greater prevalence of certain risk factors for loneliness in older age, e.g., chronic physical illnesses, disability, and loss of relationships (Penninx *et al.*, 1997; Tijhuis *et al.*, 1999). Findings about sex differences are also mixed, with reports of greater loneliness in women (Jakobsson and Hallberg, 2005; Pinquart and Sorensen, 2001; Victor and Bowling, 2012), men (Djukanovic *et al.*, 2015), or neither (Jylha, 2004; Nicolaisen and Thorsen, 2014a). Such inconsistent findings might reflect sex-related differences in loneliness risk factors, reporting biases, and divergent constructs of loneliness (Arber and Ginn, 1994; De Jong Gierveld and Van Tilburg, 2010; Tornstam, 1992).

Assessments of loneliness can be broadly grouped into 1) multiple-item scales that do not explicitly use the words "lonely" or "loneliness" and 2) single-item measures that directly ask subjects to rate frequency/severity of "feeling lonely." Commonly used multiple-item scales include the uni-dimensional UCLA Loneliness Scale Version 3 (UCLA-3) (Russell, 1996) and the multi-dimensional De Jong Gierveld Loneliness Scale that assesses social and emotional loneliness (de Jong-Gierveld and Kamphuis, 1985). Single-item measures include item #14 from the Center for Epidemiologic Studies Depression (CESD) scale (Radloff, 1977) as well as other similar inquires of "Did you feel lonely much of the time over the past week?" Multiple-item scales assess a specific conceptualization of loneliness and address the problem of potential underreporting due to stigma associated with loneliness as identified by single-item measures. This stigma may disproportionately affect male participants (de Jong Gierveld *et al.*, 2006). Nicolaisen and colleagues examined both a multiple-item scale (De Jong Gierveld Loneliness Scale) and a single-item measure of loneliness in participants aged 18–81 years, and found that women were more likely to report loneliness on the direct question while men appeared more lonely on the multiple-item scale, though only in the younger age groups (Nicolaisen and Thorsen, 2014b).

Though the relationships of loneliness with resilience and optimism have been examined (Ben-Zur, 2012; Zebhauser *et al.*, 2014), the association between loneliness and wisdom has not been investigated. Wisdom is an important but understudied entity. Discussed in religious and philosophical literature since ancient times, wisdom has only been examined empirically during the last four decades. Published studies including literature reviews, an expert consensus panel, and examination of an

ancient scripture suggest that wisdom is a complex human trait with specific components— i.e., emotional regulation, self-reflection, pro-social behaviors such as empathy and compassion, decisiveness, social advising, tolerance of divergent values, and spirituality (Jeste and Lee, 2018; Jeste *et al.*, 2010; Jeste and Vahia, 2008; Meeks and Jeste, 2009). These components have been shown to map onto specific regions of the brain – i.e., prefrontal cortex (dorsolateral and ventromedial), anterior cingulate, and limbic striatum – to form a putative neurocircuitry of wisdom (Meeks and Jeste, 2009). Based on these neurobiological foundations, our group developed a self-report scale for measuring wisdom based on those six components of wisdom, labeled San Diego Wisdom (SD-WISE) scale.

To our knowledge, there has been no study of loneliness using multiple measures of this construct in a well-characterized sample with a broad age range covering the adult lifespan, that has examined the relationships of loneliness with various negative and positive psychological traits and states, especially wisdom, as well as subjective cognitive and physical functioning. The present study examined the severity and prevalence of loneliness using three published measures of loneliness.

Based on the published literature, we hypothesized that loneliness would increase with age, but would not differ between women and men. We also hypothesized that loneliness would be associated directly with measures of worse mental, cognitive, and physical functioning; and inversely with levels of wisdom, optimism, resilience, and well-being. Lastly, we explored which factors were associated with loneliness when entered into a multivariate model.

Methods

Study participants

The current report is based on analyses of a combined data set from three study cohorts (total $N = 340$), described below. All three cohorts had several similar inclusion and exclusion criteria: 1) community-dwelling adults, 2) provision of written informed consent to participate in the study, 3) fluency in English, 4) physical and mental abilities to complete the study assessments, 5) no known diagnosis of dementia, and 6) completion of the UCLA-3 measure of loneliness. Additional selection criteria for specific studies are described below.

(I) UCSD Successful AGing Evaluation or SAGE cohort (age 21–100 years, Lifespan or LS): This study sample has been previously described (Jeste *et al.*, 2013; Thomas *et al.*, 2016). Briefly, it included 190 community-dwelling residents of San

Diego County who met the following additional inclusion criteria: 1) aged 25–100 years, and 2) had a telephone line within the home. Persons who lived in nursing homes or required daily skilled nursing care, or had a terminal illness, were excluded. Participants were recruited using list-assisted random digit dialing in the San Diego area.

(II) Healthy comparison subjects from a study of aging and mental illness (age 26–65 years, Young and Middle-aged Adults or YMA): This study cohort has also been described previously (Joseph *et al.*, 2015; Lee *et al.*, 2016a; Lee *et al.*, 2016b; Lee *et al.*, 2018). Participants ($n = 96$) were recruited from the greater San Diego area via advertisements for the parent study. Additional exclusion criteria were: 1) past or present major neuropsychiatric illness as screened by the Mini-International Neuropsychiatric Interview (MINI) (Sheehan *et al.*, 1998), 2) alcohol or other non-tobacco substance abuse or dependence within 3 prior months, and 3) diagnosis of intellectual disability disorder or a major neurological disorder.

(III) Subjects from a Retirement Community study (age 65 + years, Old Age adults or OA): The OA study cohort includes 54 residents of a senior living community in San Diego County. This is the first published report from this study cohort. Additional inclusion criteria were: 1) 65 + years of age, and 2) residence in an independent living facility. Participants were recruited within the facility, using fliers and scripted presentations.

All the study protocols were individually approved by the UC San Diego Human Research Protections Program (HRPP) and all participants provided written informed consent prior to study participation. The data were collected over a period from November 2015 though June 2018.

Sociodemographic and clinical characteristics

Trained study staff conducted structured interviews with the participants and gathered sociodemographic information on age, sex, education level, race/ethnicity, current marital status, living situation, and income. Self-administered standardized assessments were completed for depression (Patient Health Questionnaire-9 or PHQ-9) (Kroenke *et al.*, 2001), anxiety (Brief Symptom Inventory – Anxiety subscale) (Derogatis and Melisaratos, 1983), perceived stress (Perceived Stress Scale) (Cohen *et al.*, 1983), resilience (Connor Davidson Resilience Scale or CD-RISC) (Connor and Davidson, 2003), optimism (Life Orientation Test – Revised or LOTR) (Scheier *et al.*, 1994), satisfaction with life (Satisfaction with Life Scale or SWLS) (Diener *et al.*, 1985), and wisdom (San Diego Wisdom Scale or SD-WISE) (Thomas *et al.*, 2017). Shortly after its

development, SD-WISE was included in the study assessments from July 2017 onward.

Physical and mental health assessments included physical functioning and mental well-being based on the component scores from the Medical Outcomes Survey - Short Form 36 (SF-36) (Ware and Sherbourne, 1992).

Self-reported cognitive complaints

The assessment of subjective cognitive complaints included the Cognitive Failures Questionnaire that measures forgetfulness, distractibility, and false triggering (Broadbent, 1982; Rast, 2009). Please note that this is not an objective measure of cognitive function.

Loneliness measures

The 20-item UCLA Loneliness Scale (Version 3) or UCLA-3 is the most commonly used measure, with strong test-retest reliability, high internal consistency, and validity. While the word "lonely" is never used explicitly, participants rate the frequency of several experiences (e.g., "How often do you feel in tune with others around you?" or "How often do you feel left out?") on a 4-point Likert scale (options: "I never feel this way," "I rarely feel this way," "I sometimes feel this way," and "I often feel this way.") The cut-offs for loneliness severity on the UCLA-3 scale were adapted from Cacioppo and Patrick (2008) and include: Total score < 28 = No/Low Loneliness, Total score 28 - 43 = Moderate Loneliness, and Total score >43 = High Loneliness.

The 4-item Patient-Reported Outcomes Measurement Information System (PROMIS) Social Isolation scale was also used. The items overlap with the UCLA-3 (items #11, 13, 14, 18) though they are scored on a 5-point Likert scale (options: "Never," "Rarely," "Sometimes," "Usually," and "Always."). The PROMIS items include: "I feel left out," "I feel that people barely know me," "I feel isolated from others," and "I feel that people are around me, but not with me." All items assess subjective or perceived social isolation, with the first item specifically addressing distress from perceived social isolation. The scores were interpreted as being lonely if the overall score was greater than 8 (i.e., participants rated "sometimes" or higher on any of the four items.)

In order to compare the multiple-item measures with a single-item measure of loneliness, item #14 from the Center for Epidemiologic Studies Depression Scale (CESD) was completed. This item asks participants to rate the frequency of "I felt lonely" over the preceding week with the following answer options: "Rarely or none of the time," "Some or a little of the time (1–2 days)," "Occasionally or moderate amount of time (3–4 days)," and "Most or all of the time (5–7 days)" (Radloff, 1977). The scores were interpreted as being lonely if the subject rated feeling lonely "some or a little of the time" or more frequently.

Of note, the UCLA-3 and PROMIS Social Isolation scale do not inquire about a specific time period for these items, while the CESD #14 item inquires about loneliness over the past week. This suggests a critical need for development of future loneliness scales as acute loneliness may be an adaptive social-motivating response, whereas sustained/persistent loneliness is likely maladaptive, and associated with deleterious psychosocial and biological effects (Hawkley and Cacioppo, 2004).

Statistical analyses

Variables were assessed for violation of distribution assumptions (skew and kurtosis) and were log-transformed as necessary. The three study cohorts (LS, YMA, and OA) were first compared by age group. The 25–65 year old participants from the LS study were compared with the YMA cohort and the 65 + year old participants from the LS study were compared to the OA cohort. The compared samples were similar in proportion of women and loneliness scores; therefore, they were combined for subsequent analyses.

One-Way ANOVA with *post-hoc* Least Significant Difference (LSD) testing or Pearson's Chi-square tests with *post-hoc* Chi-square testing were used to assess differences in sociodemographic factors, psychological traits/states, subjective cognitive complaints, physical functioning, and loneliness measures by subgroup of loneliness severity and by sex. However, recent studies show that this two-step procedure may miss between-group differences; it is possible that there is a significant difference between two groups, while the F test is nonsignificant (Chen *et al.*, 2018).

Though prevalence of loneliness was assessed using all three measures of loneliness described above, given its broad use in the literature and excellent psychometric properties, the UCLA-3 was employed as the primary measure of loneliness severity and used in the multivariate data analyses. We used locally weighted scatterplot smoothing (LOWESS) curve fitting, a nonparametric method to fit the potential non-linear relationship between loneliness severity and age. We then modeled such relationship using a parametric cubic-spline function, which requires specification of knot/break points for the function, akin to two points to anchor a linear relationship. While the LOWESS suggests potential forms of non-linear relationship, the cubic-spline

function allows for formal testing of the suggested non-linear relationship.

We conducted bivariate correlational analysis with UCLA-3 scores as the dependent variables and other sociodemographic and clinical variables as independent variables. The Fisher r-to-z transformation was performed to compare the correlations of loneliness with other factors in women and men. Then we performed multiple regression analyses, aided by least absolute shrinkage and selection operator (LASSO) variable selection, to identify the best multivariable model of loneliness. Missing data were imputed according to the method of chained equations. There were no missing data for age, sex, and race/ethnicity. The following measures had missing data for fewer than 3% of the participants: living situation, income, depression, anxiety, perceived stress, resilience, optimism, and mental well-being. Education level and current marital status had missing data for 4-5%. The SD-WISE total score had the highest level of missing data at 36% — a direct result of this scale having been developed and added to the assessment battery only recently (Thomas *et al.*, 2017). Thus, study that started earlier (YMA) tended to have more subjects with missing SD-WISE, whereas the LS and OA subjects were more likely to have SD-WISE scores. We formally assessed this proposition by modeling missingness of SD-WISE using a logistic regression, and found that age did predict missing SD-WISE. We included age in all regression analyses to control for potential bias due to missing SD-WISE.

In the multiple regression analysis, regression coefficients were made commensurate by standardizing each variable. Independent variables were ranked by the order in which they entered the LASSO regression. LASSO overcomes various limitations of classic variable selection procedures such as multicollinearity to provide reliable selection of independent variables (Chen *et al.*, 2016). As LASSO does not attempt to maximize R^2, the R^2 value is a less-biased indicator of the variance explained by the resulting model. Independent variables selected by LASSO were entered into linear model for further trimming using backwards elimination. The model presented is the final trimmed model such that only the independent variables that are statistically significant remain in the model. We used this approach rather than the forward or stepwise selection as the backward method provides the most reliable approach for trimming statistical models (Wang *et al.*, 2017). All analyses were carried out in R.

We present effect sizes and p-values for all of these statistical tests, and interpret small-medium effect sizes (i.e., Cohen's d > .20 or r ≥ .30) as meaningful. Significance was defined as Type I error

alpha = 0.05 (two-tailed) for all analyses, and False Discovery Rate (FDR) was used to account for multiple comparisons to ensure overall Type 1 error at alpha = 0.05.

Results

Prevalence of loneliness across measures

The total sample included 340 subjects, mean age 62 (SD = 18) years, ranging from 27–101 years. Fifty percent of the participants were women. The prevalence rates varied depending on the measure of loneliness. On the UCLA-3, 76% of all subjects reported moderate to high level of loneliness, while only 38% and 8.6% of subjects reported feeling lonely on the PROMIS and CESD, respectively. The PROMIS Social Isolation scale scores were highly correlated with the UCLA-3 total score (Spearman's rho = 0.76, p < 0.001) and the UCLA-3 subscore excluding the four PROMIS items (Spearman's rho = 0.64, p < 0.001). We did not examine loneliness prevalence by age group due to the small numbers.

This sample included 96 subjects from our group's previous work that reported on loneliness in a non-psychiatric comparison group (Eglit *et al.*, 2018), which comprised the YMA cohort in the present study. Mean UCLA-3 scores were similar between the Eglit *et al.* cohort [34.7 (SD = 10.4)] and the current sample [35.9 (SD = 10.7); t_{200} = −0.8, *p* = 0.2, *d* = −0.12.]

Comparison by severity of loneliness

The subjects were compared by severity of loneliness, as defined by the UCLA-3 scores (Table 1). The three subgroups (No/Low vs. Moderate vs. High Loneliness) were similar in age, sex, race, and educational attainment. The high loneliness group was more likely to be single, live alone, and have personal income < \$35,000. Across the subgroups, high loneliness was associated with greater depression, anxiety, and perceived stress; less resilience, optimism, mental well-being, wisdom; and greater cognitive complaints. Of note, the subgroup with a moderate level of loneliness also had worse psychological traits/states (i.e., depression, anxiety, perceived stress, resilience, optimism, mental well-being, wisdom) and subjective cognition compared to the No/Low loneliness group. Although there was no significant difference in mean scores of physical functioning across all three groups on ANOVA, there was a significant difference between No/Low and Moderate Loneliness (t_{263} = 2.2, p = 0.03, d = 0.30) but no significant difference between Moderate and High Loneliness (t_{252} = −0.71, p = 0.48, d = −0.10).

y Participants by Severity of Loneliness*

O/LOW LONELINESS (A)		MODERATE LONELINESS (B)			HIGH LONELINESS (C)					POST-HOC
										SIGNIFICANT
MEAN	SD	N	MEAN	SD	N	MEAN	SD	F or X^2	p	COMPARISONS
82 (24%)			184 (54%)			74 (22%)				
60.0	17.8	184	63.0	18.0	74	59.8	19.0	1.26	0.28	
56.1%		184	47.3%	74		50.0%		1.76	0.41	
76.8%		184	80.4%		74	77.0%		0.63	0.73	
		176			71			2.99	0.56	
8.9%			9.7%			7.0%				
59.5%			52.3%			63.4%				
31.6%			38.1%			29.6%				
29.1%		176	36.9%		71	53.5%[a]		9.87	**0.007**	
9.8%[a]		177	20.3%		73	34.2%[a]		14.1	**0.001**	
		170			70			25.9	**< 0.001**	
31.6%			24.7%[a]			55.7%[a]				
12.7%			14.1%			15.7%				
16.5%			21.2%			12.9%				
39.2%			40.0%			15.7%[a]				
states										
1.1	1.8	181	2.2	2.8	72	4.6	4.4	26.6	**< 0.001**	**A < B < C**
0.67	1.8	183	1.3	1.8	74	2.3	2.8	12.1	**< 0.001**	**A < B < C**
7.9	4.8	181	10.9	4.4	72	15.3	5.7	45.6	**< 0.001**	**A < B < C**
states										
26.3	3.2	180	24.1	3.6	74	21.4	4.4	34.1	**< 0.001**	**A < B < C**
34.9	4.8	180	31.3	5.4	74	27.4	6.5	35.7	**< 0.001**	**A < B < C**
57.8	4.5	183	55.0	7.0	71	47.7	9.5	41.5	**< 0.001**	**A < B < C**
4.26	0.42	122	3.93	0.35	47	3.62	0.39	34.6	**< 0.001**	**A < B < C**
18.3	10.5	176	27.4	12.8	72	31.1	13.1	22.9	**< 0.001**	**A < B < C**
50.6	9.5	183	47.6	10.3	71	48.6	9.2	2.5	0.083	

| O/LOW LONELINESS (A) | | MODERATE LONELINESS (B) | | | HIGH LONELINESS (C) | | | | | POST-HOC |
| | | | | | | | | | | SIGNIFICANT |
MEAN	SD	N	MEAN	SD	N	MEAN	SD	F or X^2	p	COMPARISONS
23.9	2.2	184	34.7	4.6	74	51.9	6.8	675.0	< 0.001	**A < B < C**
39.3	4.6	136	45.9	5.5	54	56.8	7.1	131.0	< 0.001	**A < B < C**
0.09	0.28	181	0.26	0.54	74	1.01	0.99	50.3	< 0.001	**A < B < C**

ve complaints score, loneliness scales, depression, anxiety, and perceived stress), lower scores suggest worse functioning.
nxiety subscale; measure of anxiety (Derogatis and Melisaratos, 1983).
ience Scale; measure of resilience (Connor and Davidson, 2003).
tudies Depression Scale; measure of loneliness (Radloff, 1977).
naire; measure of forgetfulness, distractibility and false triggering (Broadbent, 1982; Rast, 2008).
ised; measure of optimism (Scheier et al., 1994).
ire-9; measure of depression (Kroenke et al., 2001).
nes Measurement Information System.
e of perceived stress (Cohen et al., 1983).
le; measure of wisdom (Thomas et al., 2017).
Short Form 36; measure of mental and physical functioning (Ware and Sherbourne, 1992).
(Version 3); measure of loneliness (Russell, 1996).

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neliness.
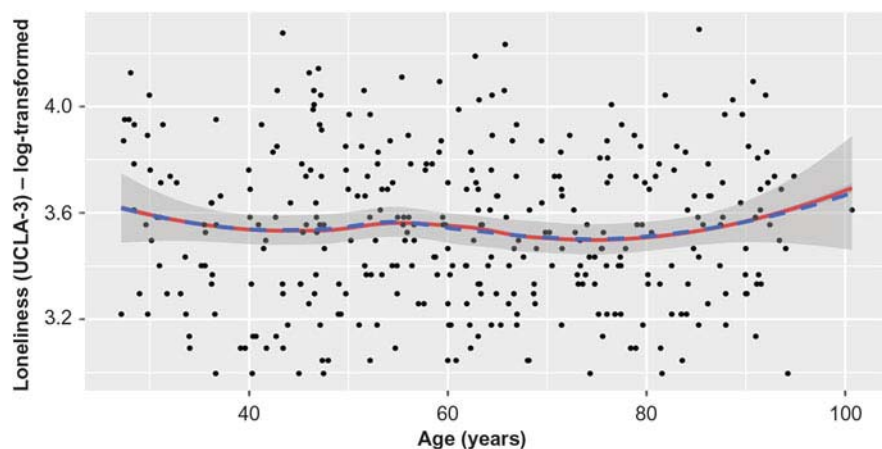ficantly different at the Bonferroni-corrected p-value level.

Figure 1. Relationship between Loneliness severity and Age (N = 340). Blue dotted line: LOESS curve fit. Red solid line: Linear spline model using age 53 year knot/break point. UCLA-3 = UCLA Loneliness Scale (Version 3); measure of loneliness (Russell, 1996). The linear spline model significantly differs from linear age effect (Wald statistic = 7.93, p = 0.019).

The women and men were similar in mean age and age distribution, education attainment, and number of children. Women and men also did not differ on depression, mental well-being, overall wisdom scores, or cognitive complaints. However, women were more likely to be currently single, live alone, as well as have lower personal incomes, worse physical functioning, greater anxiety and perceived stress, and less resilience than men (data not shown). Women and men had similar mean scores of loneliness on the UCLA-3 (35.7 (SD = 10.8) and 36.1 (SD = 10.7), respectively) and PROMIS measures (8.0 (SD = 3.5) and 8.0 (SD = 3.4), respectively), though women had slightly higher mean scores on the CESD single-item question (0.47 (SD = 0.78) and 0.29 (SD = 0.62), respectively, t_{334} = 2.33, p = 0.02). Women and men were similar in prevalence of loneliness across all three measures: UCLA-3 (73% and 79%), PROMIS (40% and 36%) and CESD (11% and 7%).

Loneliness severity was worse in the late-20s, mid-50s and late-80s

The relationship between loneliness severity (UCLA-3) and age was plotted and fitted with a spline model in Figure 1. As there was no significant age x sex interaction for loneliness, the data are shown for the entire sample. The data highlight higher levels of loneliness at three different age-points: young adulthood (late-20s), middle-age (mid-50s), and old-old (late-80s). We first examined potential non-linear relationship between loneliness severity and age using the non-parametric LOWESS curve method. We then modeled the suggested non-linear pattern using a parametric cubic-spline function, which requires specification of a knot/break point to join the two cubic functions. Thus, there is one cubic function between 20 and 53 and another cubic function between 53 and 90. When tested against the null of a

linear relationship, p-value = 0.019, which is statistically significant, ruling out random fluctuations.

Loneliness was associated with negative states and traits

Loneliness (UCLA-3) correlated with several negative states and traits. People who were more lonely also had worse depression, anxiety, perceived stress, and cognitive complaints (Table 2).

Loneliness was inversely associated with positive states, especially wisdom. People who were more lonely had lower resilience, optimism, and mental well-being (Table 2). The highest negative correlation of loneliness was with wisdom (see Figure 2). There was no statistically significant difference by sex, so the data are plotted for all subjects. Persons who were wiser were less lonely. Interestingly, very few individuals were lonely and wise, or not lonely and unwise.

Multivariate analysis

The best multiple regression model achieved with all the variables as potential correlates of loneliness is shown in Table 3. This model accounted for 45% of the variance. The first step of LASSO identified age, sex, education, living alone, income, depression, perceived stress, cognitive failures (subjective cognitive complaints), optimism, mental well-being, and wisdom. These factors were then entered into a multiple linear model and the following were found to be significant: wisdom, living alone, mental well-being as well as age, sex, perceived stress, optimism, and subjective cognitive complaints. Thus, while we did not find interactive effects, we did find independent additive effects in multiple regression analyses. The factor with the largest effect size was wisdom, followed by living alone, and then mental

Table 2. Spearman's Correlations of Loneliness in Women and Men

	TOTAL		WOMEN		MEN			
	N	rho	*N*	rho	*N*	rho	z	p
Sociodemographic Measures								
Age	340	−0.01	170	0.03	170	−0.06	0.82	0.41
Race/Ethnicity[a]	340	−0.02	170	−0.02	170	−0.01	−0.09	0.93
Education[b]	326	−0.03	164	−0.09	164	0.01	−0.9	0.37
Current marital status[c]	**326**	**0.17*****	164	0.12	**164**	**0.24****	−1.1	0.27
Living alone[d]	**332**	**−0.21*****	**165**	**−0.18***	**165**	**−0.28*****	0.95	0.34
Personal Income[e]	**319**	**−0.19****	**168**	**−0.15***	**168**	**−0.21****	0.56	0.58
Negative Psychological Traits/States								
Depression (PHQ-9)	**332**	**0.43*****	**169**	**0.45*****	**164**	**0.40*****	0.55	0.58
Anxiety (BSI)	**338**	**0.32*****	**170**	**0.33*****	**168**	**0.33*****	< 0.01	0.99
Perceived stress (PSS)	**333**	**0.49*****	**166**	**0.53*****	**168**	**0.49*****	0.49	0.62
Positive Psychological Traits/States								
Resilience (CD-RISC)	**334**	**−0.47*****	**168**	**−0.55*****	**167**	**−0.38*****	**−1.98**	**0.05**
Optimism (LOTR)	**336**	**−0.46*****	**169**	**−0.45*****	**167**	**−0.48*****	0.35	0.73
Mental well-being (SF-36)	**336**	**−0.46*****	**167**	**−0.44*****	**167**	**−0.47*****	0.34	0.74
Wisdom (SD-WISE)	**217**	**−0.53*****	**104**	**−0.51*****	**113**	**−0.56*****	0.51	0.61
Subjective Cognition								
Cognitive complaints (CFQ)	**329**	**0.38*****	**170**	**0.43*****	**166**	**0.27*****	1.66	0.10
Physical health								
Physical functioning (SF-36l)	**336**	**−0.12***	**169**	**−0.16***	167	−0.09	−0.65	0.52

BSI = Brief Symptom Inventory – Anxiety subscale; measure of anxiety (Derogatis and Melisaratos, 1983).
CD-RISC = Connor Davidson Resilience Scale; measure of resilience (Connor and Davidson, 2003).
CFQ = Cognitive Failures Questionnaire; measure of forgetfulness, distractibility and false triggering (Broadbent, 1982; Rast, 2008).
LOTR = Life Orientation Test – Revised; measure of optimism (Scheier *et al.*, 1994).
PHQ-9 = Patient Health Questionnaire-9; measure of depression (Kroenke *et al.*, 2001).
PSS = Perceived Stress Scale; measure of perceived stress (Cohen *et al.*, 1983).
SD-WISE = San Diego Wisdom Scale; measure of wisdom (Thomas *et al.*, 2017).
SF-36 = Medical Outcomes Survey - Short Form 36; measure of mental and physical functioning (Ware and Sherbourne, 1992).
[a] Race/Ethnicity is coded as: 101 = Caucasian, 102 = Non-Caucasian.
[b] Education is coded as 101 = High school and below, 102 = Some College to Bachelor's Degree, 103 = Post-Graduate Degree.
[c] Current marital status is coded as: 101 = Currently Married/Cohabitating, 102 = Currently Single.
[d] Living alone is coded as: 0 = Lives alone, 1 = Lives with someone.
[e] Personal Income is coded as: 1 = Less than $10,000, 2 = $10,000 to $19,999, 3 = $20,000 to $34,999, 4 = $35,000 to $49,999, 5 = $50,000 to $74,999, 6 = $75,000 to $99,999, 7 = $100,000 to $149,999, 8 = $150,000 or more.
* = p < 0.05, ** = p < 0.01; *** = p < 0.001.

well-being. As age was retained in both steps, these models also controlled for potential bias due to missing SD-WISE, although power was reduced because of reduced sample size.

The linear models were also run in women and men separately to assess if the factors associated with loneliness differed by sex (Table 3). In women, loneliness was associated with less wisdom, living alone, and poorer mental well-being. In men, loneliness was associated with less wisdom, living alone, and less optimism.

Discussion

We examined positive and negative psychological traits/states as well as cognitive and physical functioning as correlates of loneliness in community-dwelling individuals across adult lifespan. We found a surprisingly high prevalence of loneliness (76%) using a commonly used comprehensive scale

with excellent psychometric properties (the 20-item UCLA-3) and lower prevalence using other scales: 38% with a 4-item scale (PROMIS) and 8% with a single-item measure (CESD). Opposed to our *a priori* hypotheses, we found a non-linear relationship between loneliness severity and age, that showed increased loneliness among persons in their late-20s, mid-50s and late-80s. While we did not find sex differences in the mean UCLA-3 and PROMIS scores, women were slightly more likely to report feeling lonely on a single-item question about loneliness. Loneliness was consistently correlated with negative psychological states and traits, and inversely correlated with positive psychological states and traits, especially wisdom. The best multivariate model of loneliness included: lower levels of wisdom, living alone and worse mental well-being.

Seventy-six percent prevalence of loneliness found in this study is higher than found in most published studies of community-based samples. We

Table 3. Multiple Regression Model of Loneliness

a: Loneliness Model in Total Sample (*N* = 340)

VARIABLE	B	SE	FDR-Adjusted *p*	COHEN'S *d*
Age	−0.001	0.0007	0.04	0.11
Sex	0.05	0.02	0.03	0.12
Living alone	0.13	0.03	0.0001	**0.24**
Perceived stress	0.008	0.003	0.02	0.14
Optimism	−0.01	0.004	0.004	0.17
Mental well-being	−0.007	0.002	0.0004	**0.21**
Wisdom	−0.17	0.03	< 0.0001	**0.29**
Cognitive complaints	0.002	0.0009	0.03	0.12
b: Loneliness Model in Each Sex				
Women (*N* = 170)				
Age	−0.02	0.03	0.57	0.05
Living alone	0.13	0.04	0.003	**0.26**
Perceived stress	0.008	0.004	0.11	0.16
Optimism	−0.009	0.004	0.12	0.15
Mental well-being	−0.009	0.003	0.002	**0.28**
Wisdom	−0.19	0.04	0.0004	**0.32**
Cognitive complaints	0.002	0.001	0.24	0.11
Men (*N* = 170)				
Age	−0.06	0.03	0.15	0.14
Living alone	0.15	0.05	0.01	**0.24**
Perceived stress	0.007	0.005	0.18	0.11
Optimism	−0.02	0.006	0.04	**0.20**
Mental well-being	−0.004	0.003	0.15	0.12
Wisdom	−0.15	0.05	0.01	**0.24**
Cognitive complaints	0.002	0.001	0.15	0.12

Perceived stress measured with the Perceived Stress Scale (Cohen *et al.*, 1983).
Optimism measured with the Life Orientation Test – Revised (Scheier *et al.*, 1994).
Mental well-being measured with the Medical Outcomes Survey - Short Form 36 (Ware and Sherbourne, 1992).
Wisdom measured with the San Diego Wisdom Scale (Thomas *et al.*, 2017).
Cognitive complaints measured with the Cognitive Failures Questionnaire (Broadbent, 1982; Rast, 2008).
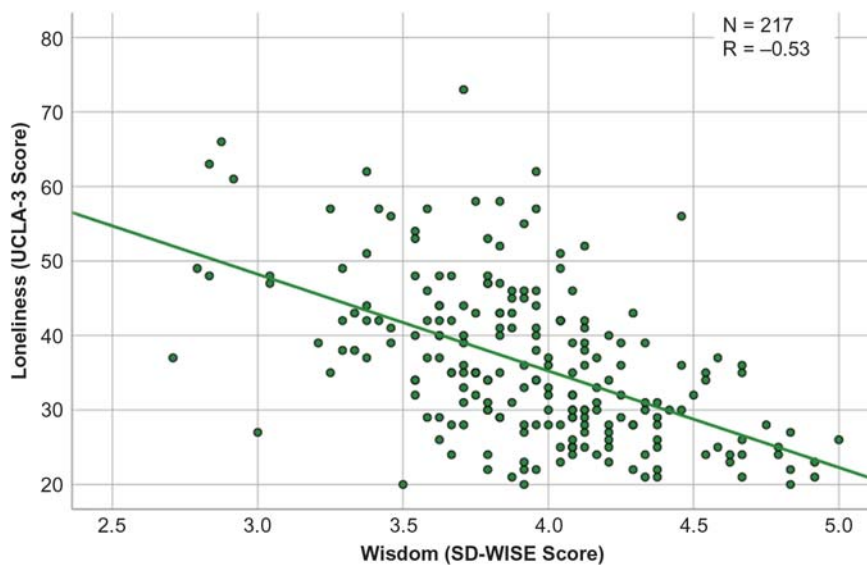
Figure 2. Wisdom and Loneliness. SD-WISE = San Diego Wisdom Scale; measure of wisdom (Thomas *et al.*, 2017). UCLA-3 = UCLA Loneliness Scale (Version 3); measure of loneliness (Russell, 1996).

examined if this higher prevalence was an artifact of sample characteristics, measures used, and severity of loneliness. 1) Our sample was community-based, with more than half of the participants being randomly selected (using random-digit dialing) and excluding institutionalized and severely medically ill persons, in whom loneliness might be even more common and severe. 2) This study used the comprehensive UCLA-3 scale. Other studies using the UCLA-3 have reported mean scores of their sample between 31 and 49 (Kong *et al.*, 2015; Russell, 1996; Springer *et al.*, 2003; Theeke and Mallow, 2013). The mean UCLA-3 score of the current study (35.9 (SD = 10.7)) falls within this range, consistent with different studies. 3) In calculating prevalence of loneliness, we categorized persons with low levels of loneliness as not being lonely. We found that even moderate levels of loneliness were associated with worse negative and positive psychological traits and states as well as worse physical functioning. We did not find a difference in physical functioning between people with moderate versus high levels of loneliness, which might be due to the exclusion of individuals with clinically significant mental or physical disabilities that might interfere with participation. The relationship between loneliness and more severe levels of disability could not be examined. Thus, our findings might be representative of moderate-severe loneliness, at least in the San Diego Community.

Loneliness prevalence may vary by measure due to different constructs of loneliness measured, reporting biases, and scale sensitivity. Single-item measures of loneliness have reported loneliness in 10%–39% of subjects (Beutel *et al.*, 2017; Nicolaisen and Thorsen, 2014b; Theeke, 2009; Victor and Bowling, 2012), while 3- to 6-item measures have reported loneliness in 24%–55% of subjects (Musich *et al.*, 2015; Nicolaisen and Thorsen, 2014b; Simon *et al.*, 2014). Multiple-item scales (that do not explicitly use the word "loneliness") were based on specific conceptualizations of loneliness, while single-item measures relied on the respondent's own concept of and willingness to report loneliness. Individuals might underreport loneliness due to stigma or social desirability bias, and this bias might be worse with the single-item measure. The lower prevalence of loneliness on PROMIS and CESD single-item in our study might reflect lower sensitivity of these brief measures compared to the more comprehensive UCLA-3 (Nicolaisen and Thorsen, 2014b). Alternatively, it is possible that the UCLA-3 scale also captures conditions that are not loneliness. Furthermore, the scales differed over the time period over which loneliness was assessed (single-item: past week, PROMIS and UCLA-3: no specific time period.)

The observed association of loneliness severity with age was consistent with some, but not all of the existing studies with broad age ranges. One study reported a U-shaped relationship between loneliness and age, such that the adolescents/young adults and oldest old were the most lonely (Luhmann and Hawkley, 2016). Other cross-sectional studies have reported greater loneliness among older adults (65 + to 80 + year olds) (Dykstra *et al.*, 2005; Perlman and Peplau, 1984; Pinquart and Sorensen, 2001; Victor and Yang, 2012). Some studies suggest that individuals of all ages overestimate the extent and impact of loneliness among older adults – than the older adults themselves report (Abramson and Silverstein, 2006; Dykstra, 2009). Loneliness varies by country and societal structure (Dykstra, 2009; Fokkema *et al.*, 2012). Longitudinal studies have reported age-related increased loneliness in older individuals, especially among the old-old (80 + years) (Dahlberg *et al.*, 2015; Houtjes *et al.*, 2014; Jylha, 2004; Samuelsson *et al.*, 1998; Tijhuis *et al.*, 1999). Many of the large population-based studies were predominantly conducted in Europe and used single-item measures of loneliness which, as mentioned above, may underestimate the prevalence of loneliness.

The relationship between age and loneliness in the present study appeared to be complex and multifaceted. While no age group seemed to be immune to loneliness, different sociodemographic variables may affect loneliness throughout the lifespan. There is also a paradox of aging: physical health declines, but mental health tends to improve with age (Jeste *et al.*, 2013; Thomas *et al.* 2016).

The correlations between loneliness and negative/positive psychosocial traits and states were consistent with other studies examining its relationships with depression, anxiety, resilience, and optimism (Ben-Zur, 2012; Zebhauser *et al.*, 2014). These findings may reflect interrelationships between loneliness and personality traits and affective states. As these negative/positive psychosocial traits and states are themselves intercorrelated, this highlights the consistency of the loneliness findings. It may be argued that certain components of wisdom such as pro-social behaviors and social advising involve good social relationships and therefore, the inverse correlation between wisdom and loneliness may be a mere tautology. We do not believe that is the case as pro-social behaviors and social advising are not necessarily related to close social relationships or networks. A compassionate person who offers advice when approached by someone else, need not be a socially engaged individual. For example, there are compassionate priests who give sound advice to a parishioner, but do not have personal networks of friends. Likewise, people with sizable social networks

may not be compassionate or known for giving wise advice to others.

The multiple regression model highlighted the importance of three factors that emerged with small-medium effect sizes. Wisdom had the largest impact on loneliness, followed by living alone and mental well-being. The influence of wisdom, as measured by SD-WISE, was present in both women and men. Positive psychological traits such as wisdom may be potentially modifiable targets for novel interventions for loneliness. Studies are needed to determine if increasing an individual's wisdom would reduce his or her loneliness and enhance well-being, and vice versa. Positive personality traits may buffer the negative influences of less modifiable factors such as older age with its associated physical and psychosocial stressors. Living alone is intercorrelated with social isolation, though it is distinct (Holt-Lunstad *et al.*, 2015). The relationship of living alone (and the other factors) with loneliness might be bi-directional, i.e., living alone might increase loneliness and loneliness might, in turn, increase social isolation.

Strengths of this study include consideration of the entire adult lifespan as well as a well-characterized cohort of persons with multiple assessments of loneliness, psychological traits and states, and health. Furthermore, all the participants were community-dwelling individuals. We used three different measures of loneliness, allowing for comparison across measures. This study also examined the relationships of loneliness with wisdom, an understudied personality trait.

Our study also had some important limitations. This was a cross-sectional study; so causality cannot be inferred. Loneliness and other psychological traits were assessed via self-reported measures, which could result in a social desirability response bias as participants may underreport negative traits. However, it should be noted that, by definition, loneliness is a subjective experience that is partially independent of the actual social network size. Loneliness measures differed over the time period of assessment. This study did not include measures of objective cognitive performance or biomarkers, which could elucidate underlying biological mechanisms mediating the relationships between loneliness and health consequences. The sample was composed primarily of educated Caucasians, which may limit the generalizability of the findings to lower SES and/or minority populations. The SD-WISE (Thomas *et al.*, 2017) total score had a high level of missing data at 36% — a result of this scale having been developed and added to the assessment battery only recently. Age was found to be a significant predictor of missing SD-WISE data. Therefore, to control for potential bias due to missing SD-WISE, age was included in all regression analyses.

Notwithstanding these limitations, loneliness (as assessed by the UCLA-3) was found to be strikingly prevalent and with a significant association with negative mental and other health outcomes. Notably, loneliness also correlated strongly and inversely with wisdom. Wisdom may be a unique protective factor against loneliness. Intriguingly, recent genetics work has reported an association between loneliness and genes expressed in the prefrontal and anterior cingulate cortices (Abedellaoui *et al.*, 2018) — areas that are also related to components of wisdom (Meeks and Jeste, 2009).

While living alone contributes to social isolation, wisdom may affect the quality of social relationships positively, and may offer a unique solution to loneliness, beyond external interventions such as support groups and facilitation of social interactions through technology and social media (Kharicha *et al.*, 2018). The published studies of technology-based interventions to date have been small and limited. Loneliness interventions may be focused *internally* to influence components of wisdom (e.g., emotional regulation, pro-social behaviors) and well-being, using technology to widely disseminate evidence-based interventions with high fidelity. Though few studies have involved comprehensive wisdom interventions, several studies have reported improvement in wisdom subcomponents, e.g., mindfulness-based stress reduction to improve self-compassion in medical students (Erogul *et al.*, 2014) and goal management training to improve emotion regulation in adults with acquired brain injuries (Tornas *et al.*, 2016).

Conclusions

The loneliness epidemic presents major societal challenges. It is deeply concerning that three-fourths of this community-dwelling sample across the adult lifespan had moderate to high level of loneliness using a comprehensive measure of loneliness. This examination of loneliness identified increased loneliness at three key timepoints: young adulthood (late-20s), middle-age (mid-50s), and old-old age (late-80s). Loneliness was associated with poor mental health and negative psychological traits. At the same time, the strong negative association between loneliness and wisdom was particularly striking and may suggest a unique solution to loneliness. Thus, loneliness and overall well-being may be improved via increasing individuals' wisdom, which includes ability to regulate emotions, self-reflect, be compassionate, tolerate opposing viewpoints, and be decisive. Thus, building a wiser society may help us build a more connected, less lonely, and happier society.

Conflict of interest

The authors have no conflicts of interest to report.

Funding

Description of author's roles

E.E. Lee conducted the literature searches and data analyses and wrote the first draft of the manuscript. C. Depp and D. Glorioso were involved in study design of the cohorts, data collection as well as data interpretation. B.W. Palmer was involved in designing two of the three parent studies, data analyses, and interpretation. R. Daly was involved with database management, data analyses, and interpretation. J. Liu and X.M. Tu were involved in data analyses and interpretation. H.C. Kim, P. Tarr, and Y. Yamada were involved with study design of the senior housing study, data analyses, and data interpretation. D.V. Jeste designed the study and was involved in the data analyses and interpretation. All authors contributed to and have approved the final manuscript.

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