Predictors of Loneliness by Age Decade:
Study of Psychological and Environmental Factors in 2,843 Community-Dwelling Americans Aged 20–69 Years

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ABSTRACT

Objective: Loneliness is a prevalent and serious public health problem due to its effects on health, well-being, and longevity. Understanding correlates of loneliness is critical for guiding efforts toward the development of evidence-based strategies for prevention and intervention. Considering that patterns of association between age and loneliness vary, the present study sought to examine age-related differences in risk and protective factors for loneliness.

Methods: Correlates of loneliness were examined through a large web-based survey of 2,843 participants (aged 20–69 years) from across the United States from April 10, 2019, through May 10, 2019. Participants completed the 4-item UCLA Loneliness Scale, San Diego Wisdom Scale (with the following subscales measuring components of wisdom: Prosocial Behaviors, Emotional Regulation, Self-Reflection, Acceptance of Divergent Values, Decisiveness, and Social Advising), and other scales measuring psychosocial variables. Multivariate regression analyses were conducted to identify the best model of loneliness and examine potential age-related differences.

Results: Age demonstrated a nonlinear quadratic relationship with loneliness (Wald statistic = 5.48, $P = .019$); levels were highest in the 20s and lowest in the 60s with another peak in the mid-40s. Across all decades, loneliness was associated with not having a spouse or partner ($P < .001$), sleep disturbance ($P < .02$), lower prosocial behaviors ($P < .001$), and smaller social network ($P < .001$). Lower social self-efficacy ($P < .001$) and higher anxiety ($P < .005$) were associated with worse loneliness in all age decades, except the 60s. Loneliness was uniquely associated with decisiveness in the 50s ($P = .012$) and with education ($P = .046$) and memory complaints ($P = .013$) in the 60s.

Conclusions: Our findings identify several potentially modifiable targets related to loneliness, including several aspects of wisdom and social self-efficacy. Differential predictors at different decades suggest a need for a personalized and nuanced prioritizing of prevention and intervention targets.

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Loneliness is a major public health problem.[1] In a meta-analysis,[2] the all-cause mortality risk (odds ratio) of loneliness in the general population was 1.49. Loneliness has an adverse impact on physical, cognitive, and mental health.[3] Efforts to prevent loneliness are critically important to advancement of public health. Evidence suggests that loneliness-focused interventions can be effective, particularly those focused on maladaptive social cognition rather than only improving social skills or networks.[4,5] In a search for potentially modifiable targets, it is helpful to consider the characteristics that are strongly associated with loneliness. Several obvious candidates include social isolation and symptoms of depression and anxiety.[6] These are commonly assessed in any mental health encounter, even initial primary care visits, and have been the key focus in loneliness interventions.[4,7] However, such interventions, while partially effective, often do not fully address chronic and persistent loneliness. It is thus important to identify additional modifiable factors. Some of the particularly strong candidates include positive psychological traits such as resilience, optimism, and wisdom. Wisdom has a particularly strong negative association with loneliness ($\rho = 0.50–0.60$). In a study of community dwelling adults, we[8] found that lower overall wisdom, as measured with the San Diego Wisdom Scale (SD-WISE),[9] was the strongest predictor of loneliness in a model that included living alone, mental well-being, age, sex, perceived stress, optimism, and subjective cognitive complaints. Wisdom comprises subcomponents that may be modifiable, but have not been widely examined, including social decision making, emotional regulation, prosocial behaviors, self-reflective behavior, acceptance of uncertainty and diversity of perspectives, and decisiveness.[10] There have also been positive findings in regard to gender, education, and ethnicity, although the specific strength and pattern of relationships have varied among studies.[9,11–14] Other correlates include inverse associations with social self-efficacy[15–17] and positive associations with chronic sleep

Clinical Points

- The epidemic of loneliness contributes to the markedly increasing rates of "deaths of despair" due to suicides and opioid abuse.
- Reducing loneliness is a public health priority, but current interventions focused solely on decreasing social isolation have been only modestly effective.
- Interventions targeting wisdom, specifically compassion or prosocial behaviors, may be a helpful addition to the armamentarium of efforts to prevent and reduce chronic loneliness and its downstream effects on health outcomes and well-being.

disturbance,[18–21] obesity,[22,23] medication use,[24,25] and cognitive decline and Alzheimer's disease pathology.[26–28] Findings in regard to social media use have been inconsistent.[6,29,30]

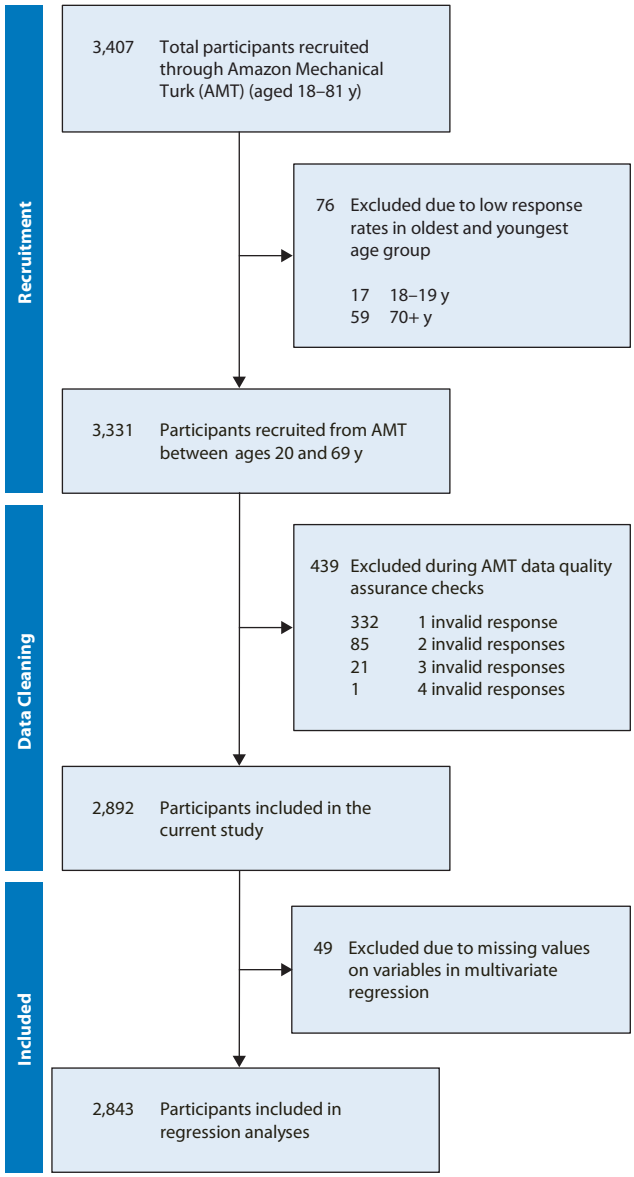
Prior research has been inconsistent in regard to the association between age and loneliness. Some studies show a linear decline, some an inverted U-pattern (peaking in middle age), and others a U-pattern (peaking in early and late adulthood).[31–33] Our previous study[8] found that loneliness was highest in the late 20s, mid-50s, and late 80s. To personalize care, it is important to consider the relative contribution of modifiable risk and protective factors in different stages of life. One prior US population-based study across the adult lifespan[6] employed multiple regression analyses to examine the relative contribution of various loneliness-related factors. The strongest predictors were social variables, including difficulty approaching others, strong social support, meaningful daily interactions, and good social life/relationship. However, that study did not include measures of positive psychosocial factors or examine differential predictors among different age groups. To our knowledge, the present study is the first large-scale survey of loneliness to examine potential age-related differences in the association of loneliness with components of wisdom, as well as sociodemographic and other positive and negative psychological and health factors. We employed a stepwise multivariate approach to identify and prioritize the smallest and most effective combination of key modifiable targets. Our hypothesis was that multivariate predictors of loneliness would include higher levels of the components of wisdom, lower severity of depression and anxiety symptoms, smaller social network size, greater sleep disturbance, and lower physical and mental well-being, as well as lower social self-efficacy, across the lifespan.

METHODS

Participants

A total of 3,407 participants aged 18–81 years were recruited through the Amazon Mechanical Turk (AMT), an online crowdsourcing marketplace,[34] from April 10, 2019, through May 10, 2019. Surveys from respondents aged < 20 and ≥ 70 years were excluded due to low response rates. Inclusion criteria for analyses were (1) age 20–69 years, (2) US resident, (3) MTurk Human Intelligence Task approval rating ≥ 90%,[34] and (4) English fluency. To further ensure data validity, we applied a data cleaning procedure to eliminate participants who provided impossible or highly implausible responses to specific survey questions (Supplementary Appendix 1). These procedures yielded a final sample of 2,892 participants. For regression models, an additional 49 participants were excluded for missing values on any variable of interest (resulting N = 2,843) (Figure 1). A waiver of documented informed consent was approved by the University of California San Diego Human Research Protections Program.

Figure 1. Flow Diagram Depicting the Flow of Participants in the Study, From Initial Recruitment Through Amazon Mechanical Turk (AMT) Through Final Inclusion in Regression Models



Measures

The survey included 90 items and required an average of 10.6 minutes to complete. Measured sociodemographic characteristics included age, sex, race/ethnicity, education, marital status, income, and living situation (number of people in household).

Loneliness was assessed using the 4-item version of the UCLA Loneliness Scale (UCLA-4),[35] which is a subset from the 20-item version of the UCLA Loneliness Scale.[36] Wisdom was assessed using the 24-item SD-WISE,[9] which includes 6 subscale scores: Prosocial Behaviors, Emotional Regulation, Self-Reflection (Insight), Acceptance of Divergent Values, Decisiveness, and Social Advising. Social network was measured with the sum of 2 items selected from the Berkman-Syme Social Network Index.[37,38] Social self-efficacy was evaluated using 4 items from the Social Self-Efficacy Scale.[39,40]

Additional measured constructs included physical and mental well-being (12-item Medical Outcomes Survey Short Form,[41,42] question on medication use), subjective cognitive decline (yes-no question), sleep disturbance (Patient-Reported Outcomes Measurement Information System Sleep Disturbance Short Form[43]), depression (2-item Patient Health Questionnaire[44]), anxiety (2-item Generalized Anxiety Disorder Scale[45]), happiness (Happiness Factor Score from the Center for Epidemiologic Studies Depression Scale[46]), resilience (2-item Connor-Davidson Resilience Scale[47]), religiosity and spirituality (2-item Brief Multidimensional Measure of Religiousness/Spirituality[48]), and a question regarding mean daily hours spent on social media for non-business reasons. See Supplementary Appendix 1 for additional description of measures.

Statistical Analyses

Statistical significance was defined as $P < .05$ (2-tailed) for all analyses. Sociodemographic characteristics and all clinical outcome variables were summarized and compared across age decades using 1-way analysis of variance for continuous variables and Pearson χ^2 tests for discrete variables. We examined the relationship between loneliness and age by fitting a locally estimated scatterplot smoothing (LOESS) curve. Then, we used spline models to model potential nonlinear relationship between these 2 variables. The LOESS curve suggests potential forms of nonlinear relationships, and the spline functions allow for formal testing of suggested nonlinear relationships.

We conducted linear multiple regression analyses with inference based on generalized estimating equations,[49] using backward elimination to identify significant covariates of loneliness. Variables with variance inflation factor > 3 were considered high for potential multicollinearity and excluded from the model. Two models were performed. First, considering that the LOESS curve and quadratic spline function indicated a nonlinear trend in the data, we modeled age as a continuous variable with a quadratic term (Model 1). We tested whether interaction terms were needed in the quadratic age model and found that adding interaction terms did not significantly improve the base model. This mean model was Loneliness = Age + Age^2 + Selected Variables. Second, because we were interested in the interaction between age decades and candidate factors, we also modeled age as a discrete variable with interaction terms between age decades and selected predictor variables (Model 2). We tested and confirmed that inclusion of interactions terms significantly improved the base model. This mean model was Loneliness = Age Decade + Selected Variables + (Age Decade × Selected Variables). All analyses were adjusted for multiple comparisons using the Holm-Bonferroni procedure to control type I error at $\alpha = .05$.

RESULTS

Sociodemographic characteristics and age group differences on all measures of interest are presented in Table 1. The mean (SD) age of the sample was 42.9 (12.7) years.

Loneliness Severity Across Age Decades

Across age decades, there was a significant difference in mean loneliness scores ($F_{4,2887} = 11.5$, $P < .001$). The relationship between loneliness and age was plotted and fitted with a LOESS curve to investigate potential nonlinear relationships (Figure 2). The data suggested that loneliness was higher in the 20s than in the 60s, with another peak in the mid-40s. We modeled this nonlinear relationship using a quadratic spline function with a single knot (break-point) at age 45 years. When tested against the null hypothesis of a linear relationship, the quadratic function was statistically significant (Wald statistic = 5.50, $P = .019$), indicating that there is one quadratic function between 20 and 44 years and another between 45 and 69 years.

Multivariate Models of Loneliness

Model 1 accounted for 52.1% variance (Table 2). Results revealed that there was a significant quadratic effect of age on loneliness (Wald statistic = 5.48, $P = .019$), such that the nonlinear curve showed a peak at 47.7 years. Greater loneliness was associated with not having a spouse or partner, greater sleep disturbance, lower prosocial behaviors, higher anxiety, lower self-efficacy, and smaller social network.

Model 2 accounted for 52.3% variance (Supplementary Table 1). Results revealed significant main effects of marital status ($P < .001$), sleep disturbance ($P = .02$), prosocial behaviors ($P < .001$), and social network ($P < .001$). Across all age decades, greater loneliness was associated with not having a spouse or partner, greater sleep disturbance, lower prosocial behaviors, and smaller social network. Additionally, there were significant interactions between age decade and education, memory complaints, decisiveness, anxiety, and social self-efficacy. Having a bachelor's degree ($P = .046$), compared to high school education, and endorsement of memory complaints ($P = .013$) were associated with greater loneliness in the 60s, but not any other decade. Lower decisiveness was associated with

Table 1. Demographic and Clinical Characteristics of the Sample (N = 2,892)[a]

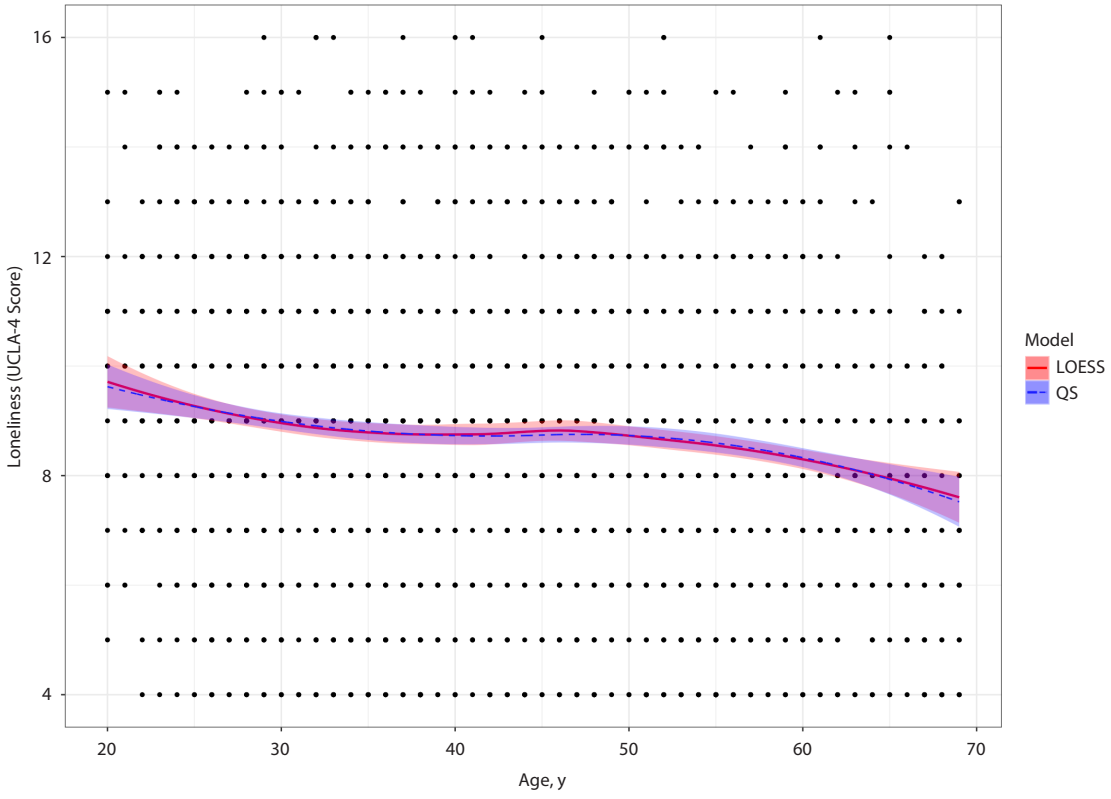
Variable	20–29 y (n = 525)	30–39 y (n = 788)	40–49 y (n = 604)	50–59 y (n = 619)	60–69 y (n = 356)	*F*	*P* Value
Sociodemographics							
Age, y	25.8 (2.6)	34.6 (2.8)	44.7 (3.0)	54.2 (2.8)	63.8 (2.8)	…	…
Female, %	49.5	50.0	55.6	67.4	63.8	65.16	<.001
Race, %							
White	59.6	70.3	77.2	81.1	89.0	154.02	<.001
African American	8.8	7.2	7.1	6.1	4.8		
Hispanic	18.9	10.8	7.0	5.3	3.1		
Asian	8.8	8.4	5.1	4.8	0.8		
Other	4.0	3.3	3.6	2.6	2.2		
Education, %						59.19	<.001
High school or below	43.9	34.4	42.2	48.9	47.6		
Bachelor's degree	46.6	48.7	40.7	36.4	33.5		
Graduate degree	9.6	16.9	17.1	14.8	18.9		
Employment status, %						361.70	<.001
Employed full-time	68.3	74.5	68.5	62.2	32.6		
Employed part-time	15.7	12.3	16.2	16.3	15.6		
Unemployed/unable to work	8.8	6.8	7.7	10.7	11.9		
Other	7.1	6.4	7.5	10.8	39.9		
Marital status (married[b])	41.7	63.2	61.4	56.9	50.8	71.31	<.001
Physical Health							
BMI	25.2 (6.2)	27.2 (6.9)	28.5 (7.4)	28.3 (6.7)	28.4 (6.4)	22.87	<.001
Medications (currently taking), %	28.4	27.4	36.6	46.2	56.5	128.03	<.001
General health rating (MOS-12)	73.3 (20.4)	72.1 (19.9)	69.0 (20.5)	68.2 (21.2)	70.4 (21.1)	6.28	<.001
Physical well-being (MOS-12)	49.5 (9.2)	50.3 (8.5)	48.2 (9.8)	45.6 (11.0)	45.3 (11.0)	30.13	<.001
Mental and Cognitive Health							
Mental well-being (MOS-12 score)	42.1 (12.2)	44 (12.1)	45.4 (11.8)	48.3 (10.6)	50.6 (10.5)	40.75	<.001
Memory complaints (yes), %	28.8	21.1	28.1	30.5	23.0	21.56	<.001
Sleep disturbance (PROMIS score)	51.6 (9.0)	50.6 (8.9)	51.2 (9.0)	49.9 (9.4)	47.3 (8.5)	14.51	<.001
Negative Psychological Features							
Loneliness (UCLA-4 score)	9.2 (2.5)	8.8 (2.7)	8.9 (2.6)	8.5 (2.6)	8.1 (2.6)	11.52	<.001
Depression (PHQ-2 score)	2.1 (1.8)	1.6 (1.7)	1.5 (1.7)	1.3 (1.6)	1.0 (1.5)	26.70	<.001
Anxiety (GAD-2 score)	2.2 (1.9)	1.8 (1.9)	1.8 (1.8)	1.3 (1.7)	1.0 (1.4)	33.33	<.001
Positive Psychological Features							
SD-WISE Wisdom score							
Prosocial Behaviors	3.7 (0.7)	3.9 (0.7)	4.0 (0.6)	4.1 (0.6)	4.2 (0.6)	50.55	<.001
Emotional Regulation	3.3 (0.8)	3.3 (0.9)	3.4 (0.9)	3.5 (0.8)	3.6 (0.8)	12.01	<.001
Self-Reflection (Insight)	3.9 (0.7)	3.9 (0.7)	3.9 (0.7)	4.0 (0.6)	4.0 (0.6)	1.28	.276
Acceptance of Divergent Values	4.0 (0.6)	3.8 (0.6)	3.9 (0.7)	3.9 (0.6)	3.8 (0.6)	3.18	.013
Decisiveness	3.1 (0.9)	3.4 (0.9)	3.5 (0.9)	3.7 (0.8)	3.8 (0.8)	38.92	<.001
Social Advising	3.6 (0.7)	3.6 (0.7)	3.6 (0.7)	3.7 (0.6)	3.6 (0.6)	0.90	.464
Total	3.6 (0.5)	3.7 (0.5)	3.7 (0.5)	3.8 (0.4)	3.8 (0.4)	18.74	<.001
Social self-efficacy (SSES score)	13.3 (3.3)	13.3 (3.4)	13.3 (3.5)	14.1 (3.2)	14.3 (3.1)	11.88	<.001
Resilience (CD-RISC score)	5.2 (1.6)	5.4 (1.8)	5.5 (1.7)	5.8 (1.6)	6.0 (1.5)	19.61	<.001
Happiness (CESD score)	7.5 (3.4)	8.0 (3.5)	7.8 (3.5)	8.5 (3.2)	9.2 (3.1)	16.81	<.001
Religiosity/spirituality (BMMRS score)	5.7 (1.9)	5.7 (2.0)	5.4 (1.9)	5.0 (2.0)	4.9 (1.9)	20.26	<.001
Social Interaction							
Social network (SNI score)	2.7 (1.4)	2.7 (1.5)	2.5 (1.5)	2.7 (1.5)	2.7 (1.5)	2.90	.021
Social media time, %						215.74	<.001
Less than 30 min	10.5	20.9	25.2	29.9	32.9		
30 min up to 1 h	14.7	25.1	27.5	26.3	27.5		
1–2 h	37.0	32.5	33.1	28.8	29.2		
3+ h	37.9	21.4	14.2	15.0	10.4		

[a]Data are presented as mean (SD) unless otherwise noted.
[b]Or living in a marriage-like relationship.
Abbreviations: BMI = body mass index, BMMRS = Brief Multidimensional Measure of Religiousness/Spirituality, CD-RISC = Connor-Davidson Resilience Scale, CES-D=Center for Epidemiologic Studies Depression Scale, GAD-2 = 2-item Generalized Anxiety Disorder Scale, MOS-12 = 12-item Medical Outcomes Survey Short Form, PHQ-2 =2-item Patient Health Questionnaire, PROMIS = Patient-Reported Outcomes Measurement Information System Sleep Disturbance Short Form, SD-WISE = San Diego Wisdom Scale, SNI = Berkman-Syme Social Network Index, SSES = Social Self-Efficacy Scale, UCLA-4 = 4-item UCLA Loneliness Scale.

greater loneliness in the 50s ($P = .012$), but not any other decade. Higher anxiety ($P < .005$) and lower social self-efficacy ($P < .001$) were associated with greater loneliness in all age decades except the 60s.

Considering the omnipresent relationships of prosocial behavior and social network with loneliness in the aforementioned models, we examined Pearson correlations and found that these bivariate correlations were significant in the total sample and in each age group (Supplementary Table 2). Post hoc χ^2 tests revealed that the strength of the relationship was significantly stronger from the 20s to the 60s ($\chi^2 = 34.7$, $P < .001$).

Figure 2. Nonlinear Relationship Between Loneliness and Age[a]



[a]Scatterplot of the relationship between loneliness and age (N = 2,843). The red line represents the locally estimated scatterplot smoothing (LOESS) curve. The blue dashed line represents the quadratic spline (QS) function. Shaded areas around lines are the 95% confidence bands.

Abbreviation: ULCA-4 = 4-item version of the UCLA Loneliness Scale.

Table 2. Multivariate Regression Model of Loneliness With Age Modeled as a Continuous Variable and Including an Age Quadratic Term (Model 1: Loneliness = Age + Age^2 + Selected Variables)

Variable	Estimate	SE	Wald Statistic	*P* Value	Partial η^2
Age, y	0.053	0.021	6.202	.013*	.002
Age^2	−0.001	< 0.001	5.475	.019*	.002
Sex	0.161	0.073	4.879	.027*	.002
Race (African American vs White)	0.438	0.144	9.235	.002*	.004
Race (Hispanic vs White)	−0.159	0.131	1.465	.226	.001
Race (Asian vs White)	−0.078	0.140	0.313	.576	< .001
Race (other vs White)	0.148	0.215	0.475	.491	< .001
Education (bachelor's degree vs high school or below)	0.099	0.079	1.593	.207	.001
Education (graduate degree vs high school or below)	0.187	0.099	3.545	.060	.001
Marital status	−0.858	0.071	144.672	< .001*	.049
Medications	−0.104	0.079	1.735	.188	.001
Memory complaints	0.298	0.085	12.209	< .001*	.004
Social media time (30 up to 60 min vs less than 30 min)	0.009	0.104	0.007	.932	< .001
Social media time (1–2 h vs less than 30 min)	−0.205	0.096	4.606	.032*	.002
Social media time (3–4 h vs less than 30 min)	−0.016	0.114	0.021	.886	< .001
General health rating (MOS-12)	−0.011	0.004	6.677	.010*	.003
Sleep disturbance (PROMIS)	0.038	0.005	62.454	< .001*	.025
SD-WISE Decisiveness	−0.205	0.052	15.674	< .001*	.006
SD-WISE Prosocial Behaviors	−0.906	0.072	159.740	< .001*	.056
SD-WISE Social Advising	−0.238	0.072	10.860	.001*	.004
SD-WISE Acceptance of Divergent Values	0.169	0.064	6.975	.008*	.003
Resilience (CD-RISC)	−0.052	0.030	3.075	.080	.001
Anxiety (GAD-2)	0.192	0.026	54.453	< .001*	.020
Social self-efficacy (SSES)	−0.134	0.014	87.565	< .001*	.034
Social network (SNI)	−0.414	0.027	233.424	< .001*	.085

*$P < .05$.

Abbreviations: CD-RISC = Connor-Davidson Resilience Scale, GAD-2 = 2-item Generalized Anxiety Disorder Scale, MOS-12 = 12-item Medical Outcomes Survey Short Form, PROMIS = Patient-Reported Outcomes Measurement Information System Sleep Disturbance Short Form, SD-WISE = San Diego Wisdom Scale, SNI = Berkman-Syme Social Network Index, SSES = Social Self-Efficacy Scale.

DISCUSSION

As hypothesized, loneliness was associated with smaller social network, fewer prosocial behaviors, lack of a spouse or partner, lower social self-efficacy, and higher sleep disturbance and anxiety symptoms. Depression did not emerge as a key predictor, contrary to our hypothesis. The relationship between loneliness and depression was accounted for by the variance associated with anxiety, which is consistent with studies showing that social anxiety is the strongest predictor of greater loneliness.[6,50] Examining trends of loneliness across age, we found that loneliness was highest in the 20s and lowest in the 60s with another peak in mid-40s. This finding replicates our previous study[8] showing that loneliness peaks in early adulthood and middle-age and supports the "paradox of aging" that psychological well-being improves after middle age despite declining physical and cognitive functioning.[51] Social network, marital status, prosocial behaviors, and sleep were consistent predictors of loneliness across all decades, which is consistent with prior research.[52–54] Although the association of general self-efficacy and loneliness has been previously examined, to our knowledge, this study is one of the first to examine social self-efficacy across the adult lifespan. This investigation is also one of the few to study the relative contributions of loneliness-related factors in multiple regression analyses in a large population-based survey[6] and the first to examine the association with components of wisdom.

Loneliness was associated with both external (eg, marital status, social network) and internal (eg, prosocial behaviors, self-efficacy) factors. Strategies to reduce loneliness have primarily focused on decreasing objective social isolation and improving social skills.[1,5] However, social network size does not necessarily translate to high-quality relationships.[5] Loneliness can still occur if people are unable to emotionally connect with and share in the experiences of their network.[50,52] Socially or interpersonally rewarding experiences are more likely to reduce loneliness than general social-group activities.[55] Interventions are likely to be more effective if they also incorporate internal factors, such as mastery of social skills and reducing maladaptive social cognitions. Our findings in regard to prosocial behaviors and social self-efficacy indicate other points of intervention. Wisdom may moderate the relationship between social network and loneliness through one's ability to demonstrate prosocial behaviors, such as compassion and social cooperation, and to accurately perceive and interpret others' emotions ("theory of mind"). Indeed, prosocial behaviors and social network are positively correlated; the strength of this relationship was stronger with increasing age, concomitant with decreasing levels of loneliness, suggesting that compassion is necessary to have a social network. Prosocial behaviors facilitate social cooperation, decreasing competition and contentious behavior. Individuals with prosocial motives are more likely to achieve better joint outcomes, which can increase social connectedness. In a recent study examining qualitative aspects of older adults' experience of loneliness, we[56] found that compassion is an important subtheme for coping with loneliness. This finding is also consistent with reports of the protective influence of volunteer work.[57] One key to prevent or reduce loneliness may be to encourage individuals to engage in volunteer work to help others.

Higher self-efficacy increases the likelihood of sustained efforts toward social connection. According to the classic perceived self-efficacy theory posited by Bandura,[58] the key to behavior change is through improved self-efficacy beliefs. Self-efficacy can be improved through guided mastery experiences and is particularly effective if the targeted behavior is modeled by a person whom individuals perceive as resembling themselves on relevant dimensions, which suggests the potential for peer-based facilitators in social self-efficacy interventions. Increasing beliefs of social self-efficacy and prosocial behaviors may improve quality of communication and connection with one's existing social environment and make one more apt to benefit from strategies to improve social network and reduce isolation. Notably, wisdom as well as prosocial behaviors can be potentially enhanced with psychosocial interventions.[59,60]

The association between impaired sleep and loneliness appears to be complex and bidirectional. Some studies have hypothesized that stress and hypervigilance to social threats associated with loneliness may impact sleep quality.[61] These relationships appear to be independent of depression,[62] though depression itself affects sleep. One study[63] found that anxiety and rumination fully mediate the relationship between loneliness and sleep quality, whereas another[54] reported that the sleep-loneliness relationship persists even after controlling for depression, anxiety, and perceived stress. Sleep may also mediate the relationship of loneliness and other health outcomes.[64] Sleep deprivation itself can lead to a behavioral profile of social withdrawal and loneliness, along with decreased functional magnetic resonance imaging brain activity in the theory of mind network (associated with understanding the intentions of others) and increased activity in a network associated with interpersonal space intrusion and that warns of human approach.[65]

There were some notable differences in predictors of loneliness across decades. Decisiveness was predictive of loneliness in the 50s. This component allows for integration of cognitive processes that are crucial to wisdom,[66] a skill that may be important in building and maintaining one's social relationships. Midlife may be a time period in which individuals have sufficiently developed this trait but also when other physical/cognitive risk factors may be less salient, making it a more relevant factor contributing to loneliness. Memory complaints were associated with greater loneliness in the 60s. Declining cognitive function may contribute to limited mobility and barriers to using technology to communicate with friends and family. Interestingly, physical health and well-being in addition to anxiety and social self-efficacy (which were associated with loneliness every other decade) were not predictors of loneliness in older adults, indicating that cognitive barriers may be more relevant than physical or

psychological ones to feeling socially connected. The finding further suggests the importance of "mind over matter"—ie, one may overcome physical barriers to connectedness (eg, access to other people) if one has social and emotional skills/qualities (eg, social self-efficacy, wisdom).

Limitations and Strengths

Our study has several limitations. We used the 4-item UCLA Loneliness Scale to minimize the length and burden of the overall survey. Using data from an independent study of community-dwelling adults,[51,67] the 4-item version was strongly correlated with the full scale ($\rho = 0.90$). AMT offers many advantages for conducting clinical and behavioral research, but potentially reduces quality of the data collected in unsupervised conditions. Consistent with standard scholarly research using AMT,[34] we applied data quality checks to ensure reliability and validity of results. Due to the large sample size, many variables were statistically significant, but the effect sizes of some covariates were small.[68,69] To increase clinical significance, variables with very small effect sizes were not interpreted (even if they reached statistical significance). Nevertheless, although each predictor may account for only a small amount of variability, together the variables help explain a large percentage of variance in loneliness (R^2 of multivariate models was large, accounting for 52% variance).

The study included a broad assessment of physical and mental/psychological traits. All data were based on self-report, which may be subject to recall and response biases. On the other hand, the anonymized nature of the online survey may contribute to respondents' feeling more comfortable to disclose negative traits and symptoms. This study did not include older adults in their 70s or 80s. Considering previous research suggesting that loneliness increases again in older age[8] and the number of risk factors predisposing older adults to loneliness (eg, smaller social network, widowhood, declines in physical health, increased prevalence of dementia), findings from this study may not be generalizable to the oldest segment of the population. Finally, the cross-sectional design limits our ability to make causal inferences. Future comprehensive longitudinal studies of loneliness, including real-time measurement of fluctuations in loneliness using ecological momentary assessment, are needed to better understand mechanisms of risk and protective factors of loneliness to better guide prevention and intervention efforts.

Despite the aforementioned limitations, the present study has several strengths, including a large sample of over 2,800 adults across 5 decades, with diversity in sex, race/ethnicity, income, and geographic region within the United States. This study of wisdom in a national sample is the largest known and one of the few to examine the relationship between wisdom and loneliness. Additionally, we examined how specific components of wisdom relate to loneliness and elucidated behavioral targets that may be appropriate for intervention.

Conclusions and Next Steps

Our findings suggest that the prosocial behaviors and decisiveness components of wisdom may be unique aspects of preventing or reducing chronic loneliness. Studies of intervention and prevention efforts should incorporate social network, prosocial behavior, and social self-efficacy modifications.[60,70] These efforts should also consider stage-of-life issues in terms of the cause and experience of loneliness within the broader context of the individual's phase of life and milestones.

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Supplementary Material

Article Title: Predictors of Loneliness by Age Decade: Study of Psychological and Environmental Factors in 2,843 Community-Dwelling Americans Aged 20–69 Years

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List of Supplementary Material for the article

1. **Appendix 1** Supplementary Methods
2. **Table 1** Multivariate regression model of loneliness with age modeled as a discrete variable and including age interaction terms (Model 2: Loneliness = Age Decade + Selected Variables + [Age Decade × Selected Variables])
3. **Table 2** Pearson's correlation between SD-WISE Pro-social behaviors and Social Network Index (SNI)

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APPENDIX 1

Participants

A total of 3,407 adult participants (ages 18-81years) were recruited through Amazon's Mechanical Turk (AMT) (www.mturk.com) from April 10, 2019 through May 10, 2019. We posted the survey on AMT using the following language, "*We are looking for people to answer questions about a variety of topics, including age, gender, mood, wisdom, and sleep, among others."* Interested workers voluntarily participated by selecting a hyperlink, which directed them to the survey. Surveys from 59 respondents age ≥ 70 and 17 respondents between ages 18 and 19 years were subsequently excluded due to low response rates.

AMT data quality has been repeatedly shown to be similar to that acquired in controlled laboratory settings.[1-4] MTurk Human Intelligence Task (HIT) approval rating for all participants were ≥ 90%, indicating that a worker's data had been deemed valid by previous requesters at least 90% of the time. To further ensure data validity, we applied a data cleaning procedure to eliminate participants who provided impossible or highly implausible responses to specific survey questions. Specifically, we excluded participants who (1) completed the survey in < 270 seconds (n = 103), (2) reported values for height ≤ 3 feet or ≥ 7 feet (n = 40), (3) reported values for height and weight leading to BMI < 16 (n = 163), (4) reported living in a household with > 20 people (n = 12), (5) reported having > 40 pets (n = 3), or (6) endorsed incongruent responses on different items of the Social Network Index (i.e., reported fewer close friends than the number of close friends seen in the last month) (n = 248). In total, 439 participants were excluded for providing seemingly invalid responses, leaving a final sample of 2,892 participants for analysis. For regression models, an additional 49 participants were excluded for missing values on any variable of interest, leaving a final sample of 2,843 for analysis (**Figure 1**). The missing data

rates were equivalent across age decades (mean = 1.17%, SD = 0.72, range = 0.65 to 2.67). The final sample used in regression analyses (N = 2,843) did not differ significantly from the original AMT recruited sample (N = 3,331) on mean age, gender, race/ethnicity, education level, marital status, or income.

Measures

In order to keep the overall survey at a tolerable length, other than the full 24-item SD-WISE, for which there is no abbreviated version, validated and published briefer versions of the measures for all other constructs were employed when available.

4-item version of the UCLA Loneliness Scale (UCLA-4).[5] Each item is scored on a scale of 1 to 4: 1= "never," 2= "rarely," 3 = "sometimes," or 4 = "always," yielding a potential range of 4 to 18, with higher scores reflect higher levels of loneliness. These four items are a subset from the full 20-item version of the UCLA Loneliness Scale – Third Edition.[6] The scale contains two negatively worded (lonely) items and two positively worded (non-lonely) items; the positively worded items are reversed scored. Higher scores reflect higher levels of loneliness. The internal consistency reliability (Cronbach's α) of the UCLA-4 was 0.718. Using data from an independent study of community dwelling adults,[7,8] the 4-item version was strongly correlated with the 20-item full scale (ρ = 0.897).

San Diego Wisdom Scale (SD-WISE).[9] The 24-item SD-WISE has been shown to have excellent psychometric properties.[9] For the present analyses we focused on the six SD-WISE subscale scores, i.e., Pro-social behaviors, Emotional regulation, Self-reflection (Insight), Acceptance of divergent values, Decisiveness, and Social advising. Higher scores reflect greater levels of wisdom. The SD-WISE had internal consistency of α = 0.72 and compares favorably to other measures of wisdom, including the Three-Dimensional Wisdom Scale (3D-WS-12) and

Self-Assessed Wisdom Scale (SAWS).[9] Construct validity was strong with high factor loadings (range: 0.54 to 0.82) and good convergent validity with the 3D-WS-12 and SAWS (r = 0.44 to 0.47).

2-item version of the Berkman-Syme Social Network Index (SNI).[10,11] Social network was measured with the sum of two items: *"How many close friends do you have, people that you feel at ease with, can talk to about private matters?"* and *"How many of these close friends do you see at least once a month?"*. Each item was scored on an ordinal scale: 0 = *none*, 1 = *one to two friends*, 2 = *three to five friends*, 3 = s*ix to nine friends*, or 4 = *ten or more friends*, yielding a potential total score of 0 to 8, with higher scores indicating a larger social network. Our survey also included two dichotomous items from the SNI (marital status and participation in social/religious/community groups), but we limited the abbreviated composite SNI to the above two items, based on results from factor analysis of all four items. Higher scores reflect larger social network. Internal consistency of the SNI was $\alpha = 0.84$. Construct validity was also high with strong negative relationships with hostility ($\phi = -0.35$) and depression ($\phi = -0.31$).[12]

4-item version of the Social Self-Efficacy Scale (SSES).[13,14] The SSES was originally developed for use with adolescents. We measured social self-efficacy using four items, with minor wording modifications. These four items were selected for age-appropriateness and included: (1) "*How well can you become friends with other people?*," (2) "*How well can you have a chat with an unfamiliar person?*," (3) "*How well can you tell other people that they are doing something you don't like?,*" and (4) "*How well can you succeed in preventing quarrels with other people?*". Response options were: 1 – "not at all," 2 – "a little bit," 3 – "pretty well," 4 – "well," and 5 – "very well," yielding a potential score range of 1 to 20. Higher scores reflect

higher social self-efficacy. Internal consistency of the Social Self-Efficacy Scale was $\alpha = 0.89$. Construct validity was strong with high factor loadings (range: 0 .64 to 0.77).

12-item Medical Outcomes Survey Short Form (SF-12).[15,16] The 12-item Medical Outcomes Study Short Form Health Survey is abbreviated from the 36-Item Short-Form Health Survey (SF-36).[17] It includes a general health rating as well as physical component and mental component summary scores, both of which have strong psychometric properties and reproduce over 90% of the variance in the SF-36 physical and mental component scores. Higher scores indicate better physical and mental well-being. The test-retest reliability of the SF-12 ranged from 0.864 to 0.890 for the physical component and 0.760 to 0.774 for the mental component. Correlations between the SF-12 and SF-36 were high ($r = 0.951$ and 0.969 for physical and mental components, respectively).

4-item Patient-Reported Outcomes Measurement Information System (PROMIS) Sleep Disturbance Short Form.[18,19] Respondents were asked to rate: (1) their sleep quality on a scale ranging from 1 (*very poor*) to 5 (*very good*) and if (2) their sleep was refreshing, (3) they had a problem with their sleep, or (4) they had difficulty falling asleep on a scale ranging from 1 (*not at all*) to 5 (*very much*). Scores were normalized to T-scores, with higher scores indicating a greater degree of sleep disturbance. The PROMIS Sleep Disturbance had high internal consistency reliability of $\alpha = 0.96$ and strong convergent validity with the Pittsburgh Sleep Quality Index ($r = 0.66$ and 0.85). The 4-item short form was strongly correlated ($r = 0.95$) with the full version.

2-item Patient Health Questionnaire (PHQ-2).[20] The PHQ-2 was used to assess for symptoms of depression. Higher scores indicate higher levels of depression. The PHQ-2 showed

internal consistency reliability of $\alpha = 0.83$ and strong convergent validity with other measures established measures of depression ($r = 0.67$ and 0.87).[21]

2-item Generalized Anxiety Disorder Scale (GAD-2).[22] The GAD-2 was used to assess for symptoms of anxiety. Higher scores indicate higher levels of anxiety. The GAD-2 has strong internal consistency reliability ($\alpha = 0.820$) and test-retest reliability (intraclass correlation coefficient of 0.811).[23,24]

4-item Happiness Factor Score from the Center for Epidemiologic Studies Depression Scale (CES-D).[25,26] Happiness was measured using four items from CES-D, on which respondents rated (on a 4-point scale) how often they had the following experiences during the previous week: "*I felt hopeful about the future*," "*I was happy*," "*I enjoyed life*," "*I felt that I was just as good as other people*." This subcomponent of the CES-D has been shown to be a valid instrument for measuring positive affect or happiness.[27-29] Higher scores indicate higher levels of happiness. Internal consistency reliability of the full CES-D was $\alpha = 0.84$ to 0.90 and test-retest reliability coefficients were between $r = 0.45$ and 0.70.

2-item Connor-Davidson Resilience Scale (CD-RISC).[30] Resilience was measured using the 2-item abbreviated version of the CD-RISC, with higher scores indicating higher resilience. The 2-item CD-RISC showed a high intraclass correlation of 86.5%, indicating good test-retest reliability, as well as strong correlations with the full scale (item-subtotal correlations was $r = 0.78$; correlation with individual full-scale items were $r = 0.27$ to 0.66.[30]

2-item Brief Multidimensional Measure of Religiousness/Spirituality (BMMRS).[31] Religiousness and spirituality was measured using the following two items from the BMMRS: "*To what extent do you consider yourself a religious person?*" and "*To what extent do you*

consider yourself a spiritual person?" Respondents were asked rated their responses on a 4-point scale from *very* to *not at all*. The internal consistency of the full BMMRS was 0.75.[31]

Subjective cognitive decline was assessed with a single item: "*Have you noticed a decline in your memory and thinking that is worrisome to you? [Yes/No]*", which has been supported by other studies.[32,33] Many self-report measures have been used to investigate SCD,[34] but there is no established gold standard method of assessment.[35] Moreover, this mode of assessment is more pragmatic and consistent with typical clinical practice.

Statistical analyses

We conducted linear multiple regression analyses in R version 3.6.1 with inference based on generalized estimating equations (GEE). GEE improves robustness of findings as it does not impose any mathematical distribution assumptions, such as normality, and provides valid inference for a broader class of data distributions.[36] Backward elimination was used to identify significant covariates of loneliness. Variance inflation factor (VIF) was employed to check for potential multicollinearity for each covariate in the GEE in two steps. First, variables with VIF > 3 were considered high for potential multicollinearity and excluded from the model. Next, backward elimination was performed on the remaining variables. In each step of backward elimination, the variable with the highest *p*-value was removed and a new model was built based on the rest of the variables. The process is repeated until all the remaining variables have $p < 0.2$.[37] VIF was calculated again, and variables with VIF > 2 were removed to obtain the final model.[38]

Two models were performed. First, considering that the LOESS curve and quadratic spline function indicated a non-linear trend in the data, we modeled age as a continuous variable with a quadratic term (Model 1). We tested whether interaction terms were needed in the

quadratic age model and found that adding interaction terms did not significantly improve the base model ($\alpha = 0.10$; Wald statistic = 54.6; $df = 46$; $p = 0.18$). This mean model was: Loneliness = Age + Age^2 + Selected Variables. Second, because we were interested in the interaction between age decades and candidate factors, we also modeled age as a discrete variable with interaction terms between age decades and selected predictor variables (Model 2). We tested and confirmed that inclusion of interactions terms significantly improved the base model ($\alpha = 0.10$; Wald statistic = 115; $df = 92$; $p = 0.06$). This mean model was: Loneliness = Age Decade + Selected Variables + (Age Decade × Selected Variables). We trimmed the model by testing each age decade by predictor interaction term. If this omnibus test was statistically significant, we compared and reported the differential predictor effects over the five age decades. Since omnibus tests may yield false negative results, i.e., the omnibus test is not significant but some individual groups are still significantly different,[39] we continued to compare effects of the predictor between different age groups and reported the age groups for which the predictor had significant differential effects. If no significant interaction was observed by either the omnibus or post-hoc tests, we reported main effects. All analyses were adjusted for multiple comparisons using the Holm-Bonferroni procedure to control type I error at α=0.05.

Given the large sample size, partial eta-squared (η^2) was calculated for each variable in the model as a measure of effect size. Partial η^2 indicates the proportion of total variance attributable to a given variable, excluding other variables from the total non-error variance. Partial η^2 values of 0.02 is considered small, 0.13 is considered medium, and 0.26 is considered large.[40]

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Supplementary Table 1. Multivariate regression model of loneliness with age modeled as a discrete variable and including age interaction terms (Model 2: Loneliness = Age Decade + Selected Variables + [Age Decade × Selected Variables])

Variable	Estimate	SE	Wald statistic	Adjusted *p*-value[†]
Sex				
20s	0.280	0.183	2.333	0.633
30s	0.091	0.134	0.462	1.000
40s	0.203	0.151	1.814	0.712
50s	0.145	0.162	0.799	1.000
60s	0.020	0.223	0.008	1.000
Race (African American vs. Caucasian)				
20s	0.237	0.327	0.525	0.937
30s	0.537	0.214	6.292	0.061
40s	0.478	0.311	2.357	0.374
50s	0.908	0.366	6.156	0.061
60s	0.090	0.430	0.044	0.937
Race (Hispanic vs. Caucasian)				
20s	-0.288	0.219	1.725	0.567
30s	0.058	0.219	0.071	1.000
40s	0.019	0.421	0.002	1.000
50s	-0.559	0.333	2.820	0.372
60s	-0.916	0.451	4.132	0.210
Race (Asian vs. Caucasian)				
20s	-0.091	0.283	0.103	1.000
30s	-0.285	0.233	1.498	1.000
40s	0.255	0.245	1.086	1.000
50s	0.154	0.348	0.197	1.000
60s	-0.418	1.975	0.045	1.000
Race (Other vs. Caucasian)				
20s	-0.591	0.494	1.433	0.925
30s	0.365	0.315	1.344	0.925
40s	0.055	0.474	0.013	1.000
50s	1.025	0.477	4.624	0.158
60s	-0.209	0.656	0.101	1.000
Education (Bachelor's degree vs. high school or below)				
20s	-0.056	0.187	0.088	1.000
30s	0.182	0.149	1.493	0.887

40s	0.049	0.178	0.076	1.000
50s	-0.139	0.163	0.727	1.000
60s	0.638	0.245	6.797	0.046*
Education (Graduate degree vs. high school or below)				
20s	0.699	0.304	5.309	0.106
30s	-0.063	0.189	0.112	1.000
40s	0.017	0.196	0.008	1.000
50s	0.348	0.228	2.338	0.505
60s	0.256	0.251	1.040	0.924
Marital status				
20s	-0.730	0.184	15.815	<0.001*
30s	-0.946	0.135	49.034	<0.001*
40s	-0.862	0.162	28.458	<0.001*
50s	-0.884	0.153	33.356	<0.001*
60s	-0.642	0.200	10.278	0.001*
Medications				
20s	0.205	0.204	1.003	0.859
30s	-0.114	0.153	0.547	0.859
40s	-0.175	0.164	1.136	0.859
50s	-0.291	0.161	3.251	0.357
60s	-0.389	0.227	2.933	0.357
Memory complaints				
20s	0.483	0.201	5.761	0.066
30s	0.133	0.171	0.601	0.941
40s	0.140	0.181	0.596	0.941
50s	0.177	0.175	1.015	0.941
60s	0.724	0.241	9.037	0.013*
Social Media Time (30-60 minutes vs. less than 30 minutes)				
20s	-0.236	0.380	0.387	1.000
30s	0.315	0.199	2.515	0.525
40s	0.113	0.206	0.302	1.000
50s	-0.332	0.205	2.627	0.525
60s	0.063	0.267	0.056	1.000
Social Media Time (1-2 hours vs. less than 30 minutes)				
20s	-0.486	0.315	2.384	0.490
30s	-0.246	0.191	1.657	0.594
40s	-0.012	0.191	0.004	0.948
50s	-0.420	0.187	5.031	0.124
60s	0.296	0.234	1.599	0.594
Social Media Time (3-4 hours vs. less than 30 minutes)				

20s	-0.425	0.315	1.817	0.782
30s	-0.029	0.208	0.020	1.000
40s	0.382	0.269	2.009	0.782
50s	-0.057	0.247	0.054	1.000
60s	0.380	0.321	1.402	0.782
General health rating (MOS-12)				
20s	-0.018	0.010	3.103	0.313
30s	<0.001	0.009	0.002	1.000
40s	-0.003	0.009	0.076	1.000
50s	-0.014	0.008	3.073	0.313
60s	-0.028	0.012	5.245	0.110
Sleep disturbance (PROMIS)				
20s	0.026	0.011	5.433	0.020*
30s	0.041	0.010	18.394	<0.001*
40s	0.057	0.011	26.014	<0.001*
50s	0.030	0.009	10.193	0.003*
60s	0.046	0.013	11.829	0.002*
SD-WISE Decisiveness				
20s	-0.190	0.128	2.217	0.410
30s	-0.210	0.092	5.222	0.089
40s	-0.136	0.105	1.673	0.410
50s	-0.357	0.118	9.165	0.012*
60s	-0.155	0.156	0.990	0.410
SD-WISE Pro-social behaviors				
20s	-0.698	0.156	20.160	<0.001
30s	-0.929	0.126	54.704	<0.001
40s	-0.882	0.155	32.461	<0.001
50s	-0.962	0.179	28.760	<0.001
60s	-1.255	0.232	29.156	<0.001
SD-WISE Social advising				
20s	-0.358	0.196	3.346	0.285
30s	-0.256	0.135	3.621	0.285
40s	-0.104	0.143	0.526	0.602
50s	-0.164	0.153	1.149	0.602
60s	-0.299	0.234	1.638	0.602
SD-WISE Acceptance of divergent values				
20s	0.200	0.152	1.720	0.759
30s	0.149	0.123	1.474	0.759
40s	0.130	0.145	0.810	0.759
50s	0.312	0.127	6.010	0.071

60s	0.044	0.175	0.063	0.802
Resilience (CD-RISC)				
20s	-0.002	0.069	0.001	1.000
30s	-0.049	0.053	0.836	1.000
40s	-0.022	0.063	0.124	1.000
50s	-0.118	0.059	4.011	0.226
60s	-0.050	0.096	0.265	1.000
Anxiety (GAD-2)				
20s	0.186	0.060	9.720	0.005*
30s	0.250	0.048	27.008	<0.001*
40s	0.194	0.052	13.632	0.001*
50s	0.172	0.055	9.756	0.005*
60s	0.004	0.088	0.002	0.964
Social self-efficacy (SSES)				
20s	-0.166	0.037	20.405	<0.001*
30s	-0.132	0.026	26.282	<0.001*
40s	-0.148	0.030	24.200	<0.001*
50s	-0.134	0.030	19.712	<0.001*
60s	-0.064	0.043	2.198	0.138
Social network (SNI)				
20s	-0.288	0.067	18.762	<0.001*
30s	-0.447	0.047	91.874	<0.001*
40s	-0.482	0.056	74.369	<0.001*
50s	-0.366	0.057	41.352	<0.001*
60s	-0.462	0.090	26.286	<0.001*

* $p < 0.05$

† The Holm-Bonferroni procedure was used to control type I error at $\alpha = 0.05$ to account for multiple comparisons.

CD-RISC = Connor-Davidson Resilience Scale; GAD-2 = Generalized Anxiety Disorder Scale; MOS-12 = Medical Outcomes Survey Short Form; PROMIS = Patient-Reported Outcomes Measurement Information System Sleep Disturbance Short Form; SD-WISE = San Diego Wisdom Scale; SE = standard error; SNI = Berkman-Syme Social Network Index; SSES = Social Self-Efficacy Scale

Supplementary Table 2. Pearson's correlation between SD-WISE Pro-social behaviors and Social Network Index (SNI)

			Post-hoc pairwise comparisons between decades (*p*-values)				
Age Group	**Pearson's *r***	***p*-value**	**20s**	**30s**	**40s**	**50s**	**60s**
Total Sample	0.240	0.033	--	--	--	--	--
20s	0.094	<0.001	--	0.044	<0.001*	<0.001*	<0.001*
30s	0.208	<0.001		--	0.039	0.094	<0.001*
40s	0.317	<0.001			--	0.7	0.032
50s	0.296	<0.001				--	0.012
60s	0.449	<0.001					--

Post-hoc pairwise comparisons between age groups were conducted using Chi-square tests.
*$p < 0.005$ following Bonferroni correction for multiple comparisons