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Associations of Social Isolation and Loneliness with the Onset of Insomnia Symptoms among Middle-Aged and Older Adults in the United States: A Population-Based Cohort Study

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Abstract

There is inconsistent conclusion for the relationship of social isolation and loneliness with poor sleep. We investigated the associations of social isolation and loneliness with new-onset insomnia symptoms in a nationally-representative sample of 9,430 adults aged ≥50 who were free of any insomnia symptoms/sleep disorders at baseline (wave 12/13) and followed up to 4 years from the Health and Retirement Study. Social isolation was measured by Steptoe's Social Isolation Index. Loneliness was measured by the revised 3-item UCLA-Loneliness Scale. Insomnia symptoms were quantified using the modified Jenkins Sleep Questionnaire. During a mean follow-up of 3.52 years, 1,522 (16.1%) participants developed at least one insomnia symptom. Cox models showed that loneliness was associated with the onset of difficulties initiating or maintaining sleep, early-morning awakening, nonrestorative sleep, and at least one of these symptoms after adjusting for potential covariates; while social isolation was not associated with the onset of difficulties maintaining sleep, early-morning awakening, or at least one insomnia symptom after adjusting for health indicators. These results are consistent in sensitivity analyses and stratified analyses by age, sex, race/ethnicity, and obesity. Public health interventions aimed at fostering close emotional relationships may reduce the burden of poor sleep among middle-aged and older adults.

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Conflict of Interest Disclosures

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Keywords

Social Relationship; Social Connection; Sleep Disturbance; Sleep Disorders; Survival Analysis

1. Introduction

Aging is often accompanied by sleep disturbance, which is defined as impaired sleep quality and insomnia symptoms (Kocevska et al., 2020). Nearly half of older adults aged ≥65 experienced insomnia symptoms (Miner & Kryger, 2017), including difficulty initiating sleep, difficulty maintaining sleep, early-morning awakening, and nonrestorative sleep (Bloom et al., 2009). Research suggests that insomnia symptoms are associated with higher risks of cardiovascular diseases (He et al., 2017), dementia (Beydoun et al., 2021), increased hospitalization and nursing home admission (Kaufmann et al., 2013), and mortality (Mahmood et al., 2022). The health burden attributable to insomnia is expected to rise in response to worldwide population aging.

Meaningful social connection is a fundamental aspect of the human experience (Cacioppo & Cacioppo, 2018). Social isolation and loneliness are two distinct concepts that tend to be only weakly correlated (J. McHugh et al., 2017). Social isolation refers to the lack of social connections or interactions with others, while loneliness represents a perceived discrepancy between one's actual and desired social relationships (National Academies of Sciences, Engineering, and Medicine, 2020). Individuals having frequent social contact with others may feel lonely; conversely, socially isolated individuals can be satisfied with their social relationships (National Academies of Sciences, Engineering, and Medicine, 2020; Qi, Pei, et al., 2022). Both social isolation and loneliness have been linked to various negative health outcomes, including psychological distress, cardiovascular diseases, cognitive impairment/dementia, suicide risk, and even premature mortality (Evans et al., 2019; Holt-Lunstad et al., 2015; Motillon-Toudic et al., 2022; Qi, Zhang, et al., 2022; Valtorta et al., 2016). It is well-recognized that these health outcomes are associated with insomnia symptoms (Kocevska et al., 2020; Liu et al., 2020). However, mixed evidence exists for the influences of social isolation and loneliness on sleep disturbance in the adult population, and there is no consensus about the independent effects of social isolation and loneliness on sleep disturbance. Some studies have reported that social isolation, but not loneliness, was associated with sleep disturbances (Yu et al., 2018). Other studies have reported that only loneliness was associated with sleep disturbances (Kurina et al., 2011; J. E. McHugh & Lawlor, 2013; J. McHugh & Lawlor, 2011). Lastly, a few studies have suggested that both social isolation and loneliness are associated with sleep disturbance (Benson et al., 2021; Cho et al., 2019). Possibilities for these discrepancies are that the associations may be affected by risk factors that were not consistently considered (Griffin, Williams, Mladen, et al., 2020) or methodological deficiencies (e.g., small sample size (Kurina et al., 2011), homogenous sample (J. E. McHugh & Lawlor, 2013; J. McHugh & Lawlor, 2011), lack of representativeness of the population) (Benson et al., 2021; Cho et al., 2019; Yu et al., 2018) in previous studies. Although one recent meta-analysis examined the association between loneliness and sleep quality, the synthesized results suggest that longitudinal relationship between loneliness and sleep remains unclear (Griffin, Williams, Ravyts, et al., 2020). To

address these limitations, there is a need to further examine these associations by using a large representative sample that covers diverse populations.

Existing studies have focused on insomnia as a generic condition, but little is known about whether social isolation and loneliness are uniquely associated with specific insomnia symptoms. Nonrestorative sleep is a distinct insomnia symptom that occurs independently of other symptoms, including difficulties initiating or maintaining sleep (Roth et al., 2010). These symptoms are key components of diagnosing insomnia according to the DSM-5 (American Psychiatric Association & American Psychiatric Association, 2013) and International Classification of Diseases-11(Olufsen et al., 2020). However, little is known about the relationships between the onset of specific insomnia symptoms with social isolation and loneliness. These knowledge gaps introduce challenges to developing targeted interventions for poor sleep later in life. We aimed to extend the existing literature by examining the association of social isolation and loneliness, individually and simultaneously, with the onset of insomnia symptoms in a nationally-representative sample of middle-aged and older adults in the United States (US).

2. Methods

2.1. Data source

Data were from the Health and Retirement Study (HRS), which is a nationally-representative, longitudinal survey of middle-aged and older adults in the United States, conducted since 1992. The HRS has been designed specifically to investigate the health, economic, and social factors that impact the well-being of individuals as they age (Sonnega et al., 2014). Its rich and comprehensive data, collected biennially, include information on demographics, socio-economic status, physical and mental health, health behaviors, social connections, and caregiving. Additional details on the sample design and procedures have been described previously (Sonnega et al., 2014). Importantly, the HRS utilizes standardized and validated measures of sleep quality, social isolation, and loneliness, ensuring the reliability and validity of our findings. Furthermore, the longitudinal design of the HRS enables us to examine the temporal relationships between these variables and control for potential covariates, thereby increasing the rigor and validity of our analyses. The reporting of this study conforms to the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines.

2.2. Study population

Since wave 8, HRS initiated a mixed-mode follow-up, whereby 50% of random subsamples were assigned to in-person follow-up, and the remaining 50% were assigned to telephone follow-up. The in-person follow-up group was requested to complete and return by postal mail the Psychosocial and Lifestyle Questionnaire (PLQ) that collects psychosocial characteristics (e.g., social isolation, loneliness). The PLQ response rate among interviewees was around 90% (Smith et al., 2017). Furthermore, three out of four insomnia symptoms were not evaluated in the HRS wave 9 and wave 11 (Mahmood et al., 2022). To ensure the measurements of social isolation and loneliness precede insomnia symptoms, we restricted our sample to 13,892 HRS participants who completed the PLQ in wave 12 or wave

13. We then applied the following exclusion criteria: participants aged <50 (n = 315), and participants who reported having insomnia symptoms or physician-diagnosed sleep disorders at baseline (n = 3,072), as the study aimed to investigate new-onset insomnia symptoms. Additionally, we were unable to include 302 participants with missing social isolation or loneliness data due to the unavailability of complete information for our analysis. Lastly, we noted that 773 participants were lost to follow-up and not included in the final analytic sample. After applying these exclusions and accounting for participants lost to follow-up, the final analytic sample included 9,430 participants (see Figure 1 for sample selection). Included participants were younger, more likely to be white, more educated, higher income, and had lower levels of depressive symptoms and fewer chronic conditions than those excluded from these analyses (all $P < .001$).

2.3. Measures

2.3.1. Social isolation—Social isolation was estimated at baseline using the Steptoe's Social Isolation Index that was first validated in the English Longitudinal Study of Aging (Steptoe et al., 2013) and adapted to the HRS (Crowe et al., 2021; Qi, Pei, et al., 2023). We assigned a social isolation score to each participant based on whether they 1) were unmarried or not cohabiting, 2) had less than monthly contact (whether face-to-face, written, or telephone) with children, 3) had less than monthly contact with other family members, 4) had less than monthly contact with friends, and 5) did not participate in any religious groups, clubs, or other social organizations, yielding scores 0–5. We followed the procedure of previous studies (Qi, Ng, et al., 2023; Steptoe et al., 2013) and classified participants in the top quintile of scale scores as socially isolated (scoring ≥2).

2.3.2. Loneliness—Loneliness was estimated using the revised 3-item UCLA Loneliness Scale at baseline (Hughes et al., 2004). Participants rated how frequently they felt 1) lacking companionship, 2) left out, and 3) isolated from others on a 3-point scale. Previous analysis showed that this 3-item version had similar psychometric properties to the original 20-item version (Hughes et al., 2004). This 3-item version has been used extensively in this population (Crowe et al., 2021; Qi, Belsky, et al., 2023; Qi, Pei, et al., 2023). We coded item responses so that higher scores correspond to a higher loneliness level. Final scores ranged from 3 to 9. We followed the same procedure used for social isolation and classified participants in the top quintile of scale scores as lonely (scoring ≥6).

2.3.3. Insomnia symptoms—Insomnia symptoms were estimated using a modified version of the Jenkins Sleep Questionnaire, a validated and widely used screening tool that measures self-reported insomnia symptoms (Jenkins et al., 1988). Participants were asked how often they 1) had trouble falling asleep, 2) woke up during the night, 3) woke up too early and were unable to fall asleep again, and 4) felt really rested when waking up in the morning. The responses were "most of the time," "sometimes," and "rarely or never." We defined individuals as experiencing a specific insomnia symptom if they answered "most of the time" or "sometimes" to the first three questions and "rarely or never" or "sometimes" to the fourth question (Beydoun et al., 2021; Kaufmann et al., 2013).

2.3.4. Covariates—Baseline covariates were selected based on previous studies on social isolation, loneliness, and sleep disturbance (Benson et al., 2021; Cho et al., 2019; Yu et al., 2018). Participants reported their socio-demographic characteristics, including age, sex, race/ethnicity, education, and income. Lifestyle includes smoking, alcohol consumption, and physical exercise. Additionally, health indicators include obesity (body mass index ≥30 kg/m^2), depressive symptoms, activities of daily living (ADL), cognitive function, and chronic conditions. Details of measurement for each covariate are reported in the Supplementary Table S1.

2.4. Statistical analysis

Baseline characteristics were compared between participants who are isolated vs. non-isolated or lonely vs. not lonely using *t*-tests for continuous variables and Chi-square tests for dichotomous variables. No issues with multicollinearity were detected using variance inflation factors (all ≤ 2.0). Cox models that satisfied the proportional hazard assumption were performed to calculate hazard ratios (HRs) and 95% Confidence Intervals (CIs). Individuals who did not develop insomnia symptoms, died, or were lost to follow-up were censored at their last assessment. We fitted five separate models to discern the extent to which socio-demographic, lifestyle, health characteristics, and loneliness explained observed associations between social isolation and the onset of at least one insomnia symptom over a 4-year follow-up [Model 1: unadjusted. Model 2: adjusted for demographic characteristics. Model 3: further adjusted for lifestyle factors. Model 4: further adjusted for health indicators. Model 5: further adjusted for loneliness]. Similar models were fitted to test the independent associations of loneliness with insomnia symptoms. There was a small percentage of missing data on covariates (all <3.7%). All non-missing data points were used in the analyses. Cox models were stratified by age (50–64, 65–75, >75 years), sex (men, women), race/ethnicity (white, black, Hispanics), and obesity (yes, no) at baseline to assess potential modification effects because of major differences in the prevalence and risk factors of insomnia symptoms in these subgroups (Kocevska et al., 2020). Cox models were also used to determine the independent associations of social isolation and loneliness with the onset of each specific insomnia symptom at follow-ups.

Sensitivity analyses were performed. First, social isolation and loneliness were analyzed as continuous variables. Second, although complete case analyses were conducted in primary analyses, we also conducted multiple imputations for missing values (Sullivan et al., 2017). We created 10 imputed data sets using multivariate imputation by chained equations (MICE), including all variables used in the analysis and combined each estimate based on Rubin's rule (White et al., 2011).

HRS's sampling weights were applied to all analyses to account for the unequal probability of participants' selection. All analyses were conducted using Stata version 17 MP (StataCorp, 2022). A two-tailed $P < .05$ indicated statistical significance.

3. Results

The mean age of the participants was 68.0 years (SD 10.2), 58.3% were women, and 1,522 had developed at least one insomnia symptom (16.1%). Specifically, 1,394

(14.8%) participants reported difficulties initiating sleep, 1,108 (11.7%) reported difficulties maintaining sleep, 1,333 (14.1%) reported early-morning awakening, and 1,225 (13.0%) reported nonrestorative sleep. Table 1 shows the characteristics of all participants and subgroups based on social isolation and loneliness. Significant differences in participants' characteristics were observed between non-isolated vs. isolated and non-lonely vs. lonely groups. Being socially isolated or lonely was associated with being a person reporting a racial/ethnic minority background, less education, less income, and being a current/former smoker or less physically active, being ADL impaired, having more depressive symptoms, lower levels of cognitive function, and more chronic conditions.

Figure 2 presents the adjusted associations of social isolation with the onset of at least one insomnia symptom. In the unadjusted model, HR for the isolated group was 1.37 [95% CI 1.23–1.52; $P < .001$] compared with the non-isolated group. Adjusting for other covariates, including socio-demographics and lifestyle, did not substantially affect the estimates. However, when health indicators were adjusted, the association was attenuated and became insignificant (HR, 1.06; 95% CI, 0.95–1.17; $P = .460$).

The unadjusted HR for loneliness was statistically significant (1.91; 95% CI 1.71–2.12; $P < .001$, Figure 3). This association was only slightly reduced when additional adjustments were made for socio-demographic, lifestyle, and health indicators (HR, 1.55; 95% CI, 1.38–1.74; $P < .001$). HR also remained unchanged (HR, 1.55; 95% CI, 1.37–1.74; $P < .001$) when social isolation was additionally considered. The full Cox models, including all variables, are shown in the Supplementary Table S2.

Stratified analyses by age, sex, race/ethnicity, and obesity at baseline were then conducted (Supplementary Table S3). Results followed a pattern similar to that described earlier. The association of loneliness with the onset of at least one insomnia symptom was significant across different stratifications. For social isolation, further adjustment for health indicators reduced the HRs but became insignificant in stratified subgroups.

The same approach was used to examine the associations of social isolation and loneliness with the onset of each insomnia symptom (Table 2). Loneliness was associated with the onset of difficulties initiating or maintaining sleep, early-morning awakening, and nonrestorative sleep adjusting for all covariates (HR, 1.17–1.49, all $P < .01$). Social isolation was associated with the onset of difficulty maintaining sleep (HR, 1.15; 95% CI, 1.01–1.31; $P < .05$) and early-morning awakening (HR, 1.19; 95% CI, 1.06–1.34; $P < .01$), but not with the onset of difficulty initiating sleep (HR, 1.09; 95% CI, 0.98–1.22; $P = .103$) or nonrestorative sleep (HR, 1.11; 95% CI, 0.99–1.26; $P = .083$) after adjusting for health indicators.

The sensitivity analysis showed that applying continuous measures of social isolation and loneliness did not change the results from those in the dichotomous measures, with the fully-adjusted HRs for the onset of at least one insomnia symptom 1.13 (95% CI, 1.10–1.17; $P < .001$) for every unit increase in loneliness but no significant association with social isolation (HR, 1.04; 95% CI, 0.99–1.08; $P = .102$; Supplementary Table S4). The results of the sensitivity analysis that imputed the missing values using MICE were essentially

unchanged from those of the complete-case analyses (social isolation: HR, 1.04; 95% CI, 0.93–1.15; $P = .525$; loneliness: HR, 1.53; 95% CI, 1.37–1.71; $P < .001$; Supplementary Table S5).

4. Discussion

In this 4-year population-based prospective cohort study in adults aged 50 and older, we found that loneliness was associated with the onset of any insomnia symptoms, including difficulties initiating or maintaining sleep, early-morning awakening, and nonrestorative sleep. The associations were independent of social isolation and other potential covariates. The association of social isolation with the onset of difficulty initiating sleep, nonrestorative sleep, and at least one insomnia symptom became insignificant when baseline health indicators (e.g., obesity, depressive symptoms, activities of daily living, cognitive function, and chronic conditions) were considered, suggesting that the association may be driven partly by health status.

The present findings are consistent with most existing studies concerning loneliness as a significant and independent risk factor for sleep disturbance. In a recent meta-analysis of 16 studies involving 23,485 participants, Deng et al. concluded that lonely older adults were more likely to suffer from sleep disturbances than their counterparts without loneliness (Deng et al., 2023). In a cross-sectional study of 759 US older adults, increased loneliness was associated with actigraphy-estimated disrupted sleep and short sleep duration, self-reported insomnia symptoms (Benson et al., 2021), In contrast, a longitudinal study of 639 older adults in Taiwan found that the association between loneliness and sleep disturbances was insignificant after controlling for demographic and health-related factors (Yu et al., 2018). A possible explanation for this discrepancy includes differences in the operationalization of exposure and outcome variables. For example, the study in Taiwan (Yu et al., 2018) used a single item regarding the perception of loneliness in the last week to measure loneliness rather than the UCLA Loneliness Scale in our study.

Several explanations have been proposed for the underlying mechanisms by which loneliness affects insomnia symptoms. First, from an evolutionary perspective, humans must have relied on a safe environment to survive and thrive (Cacioppo & Cacioppo, 2018; Hawkley & Cacioppo, 2010). The absence of secure social surroundings may result in feelings of loneliness, that in turn, heighten feelings of vulnerability and unconscious vigilance to social threats, which are the opposite of relaxation and sound sleep (Hawkley & Cacioppo, 2010). Second, stress has been shown to significantly mediate associations between loneliness and sleep disturbances (J. E. McHugh & Lawlor, 2013). Feelings of loneliness have the potential to deplete individuals physically by impairing their sleep at night and contributing to daytime exhaustion (Hawkley & Cacioppo, 2010). Such exhaustion might result in a vicious cycle between stress and sleep, affecting sleep quality and causing additional worries of difficulty falling asleep (Aanes et al., 2011). Therefore, persistent intrusive thoughts about how to inadequately satisfy one’s needs in social interactions will lead to new-onset insomnia symptoms. Furthermore, from a psychophysiological perspective, loneliness can lower immune system function and raise

neuroendocrine dysregulation (Walker et al., 2019), both of which are associated with sleep disturbances and may induce insomnia symptoms (Floam et al., 2015).

Social isolation was unassociated with insomnia symptoms after health indicators were considered. It is possible that social isolation is associated with other health-related risk factors for insomnia, so that in multivariate analysis it does not emerge as an independent risk factor. This finding is consistent with several systematic reviews which conclude loneliness may contribute more to sleep disturbance than social isolation (Choi, 2015; Deng et al., 2023). When each insomnia symptom was analyzed separately, insignificant associations were found for difficulties initiating sleep and nonrestorative sleep. Indeed, difficulty initiating sleep is more strongly associated with depression than difficulties maintaining sleep and early-morning awakening (Chen & Saito, 2021; Ikeda et al., 2017), and individuals who experience difficulties initiating sleep or nonrestorative sleep often have a poorer health status (e.g., cardio-cerebral vascular diseases) than individuals with difficulties maintaining sleep and early-morning awakening (He et al., 2017). Thus, difficulties initiating sleep and nonrestorative sleep may simply be indicators of poor health, and the associations of social isolation with them could be explained by pre-existing health status. This also suggests that social isolation might influence insomnia in complex ways that cannot be robustly assessed with subjective measures of insomnia symptoms. Previous studies have suggested a relationship between increased screen time, particularly in the evening hours, and poor sleep quality, as exposure to blue light emitted from screens can disrupt circadian rhythms and delay the onset of sleep (Gradisar et al., 2013). In addition, the advancement in social media and the constant connectivity it provides may contribute to feelings of social isolation and loneliness, even when individuals are physically surrounded by others (Primack et al., 2017). In light of these findings, our study further emphasizes the importance of addressing both the emotional and technological aspects of modern life that may contribute to the onset of insomnia symptoms among middle-aged and older adults.

4.1. Strengths & limitations

To our knowledge, this is the first large-scale study to investigate the associations of social isolation and loneliness with insomnia symptoms in a nationally-representative sample of middle-aged and older adults. Nevertheless, several limitations should be noted. First, insomnia symptoms were evaluated using a self-reported questionnaire, and no objective measurements were available in HRS. Second, insomnia symptoms in this study may reflect different sleep disorders, such as obstructive sleep apnea. However, stratifying for two obstructive sleep apnea risk factors (i.e., age and obesity) did not change the results from the main analyses. Third, the duration of insomnia symptoms (e.g., at least three nights a week for three consecutive months in DSM-5) is important for the insomnia diagnosis. Nevertheless, due to the way in which the questions about insomnia symptoms were asked, we were unable to determine the period of time of having these insomnia symptoms. Fourth, there may be survival bias in the current study because those who remained in the study were younger, with higher socioeconomic and health status at baseline. Fifth, it has been shown that depressive symptoms, including major depressive disorder (MDD), can influence both sleep quality and social relationships (Baglioni et al., 2011; Wakefield et al., 2020). However, the information on MDD is not included in HRS. Future studies are needed to

investigate the complex interplay between loneliness, MDD, and insomnia to gain a better understanding of the mechanisms at play and inform targeted interventions. Finally, reverse causality could not be eliminated as a potential explanation for the observed associations since individuals with insomnia symptoms may suffer from greater feelings of loneliness (Griffin, Williams, Mladen, et al., 2020; Hom et al., 2020). Future research should continue disentangling the complex relationship between psychosocial factors and insomnia using both subjective and objective instruments (e.g., actigraphy, polysomnography).

5. Conclusions

In this 4-year population-based prospective cohort study in US middle-aged and older adults, loneliness was associated with difficulties initiating or maintaining sleep, early-morning awakening, nonrestorative sleep, and at least one of these insomnia symptoms. The associations were independent of social isolation, socio-demographics, lifestyle, and health factors. Individuals' sleep may benefit from psychosocial interventions toward fostering close emotional relationships. Programs that aim to change individuals' social and interpersonal interactions may reduce loneliness, thereby preventing the onset of insomnia symptoms with age and potentially reducing the excess burden of poor sleep.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Data availability statement

The Health and Retirement Study (HRS) datasets are publicly available at the University of Michigan Institute for Social Research. Researchers may obtain the datasets after sending a data user agreement to the HRS team (https://hrs.isr.umich.edu/data-products).

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Highlights

- Loneliness was associated with the onset of difficulties initiating or maintaining sleep, early-morning awakening, nonrestorative sleep, and any of these insomnia symptoms after adjusting for socio-demographics, lifestyle, health indicators, and social isolation.
- Social isolation was not significantly associated with the onset of difficulties maintaining sleep, early-morning awakening, or at least one insomnia symptom after adjusting for health indicators.
- Public health interventions aimed at fostering close emotional relationships may reduce the burden of poor sleep among middle-aged and older adults.

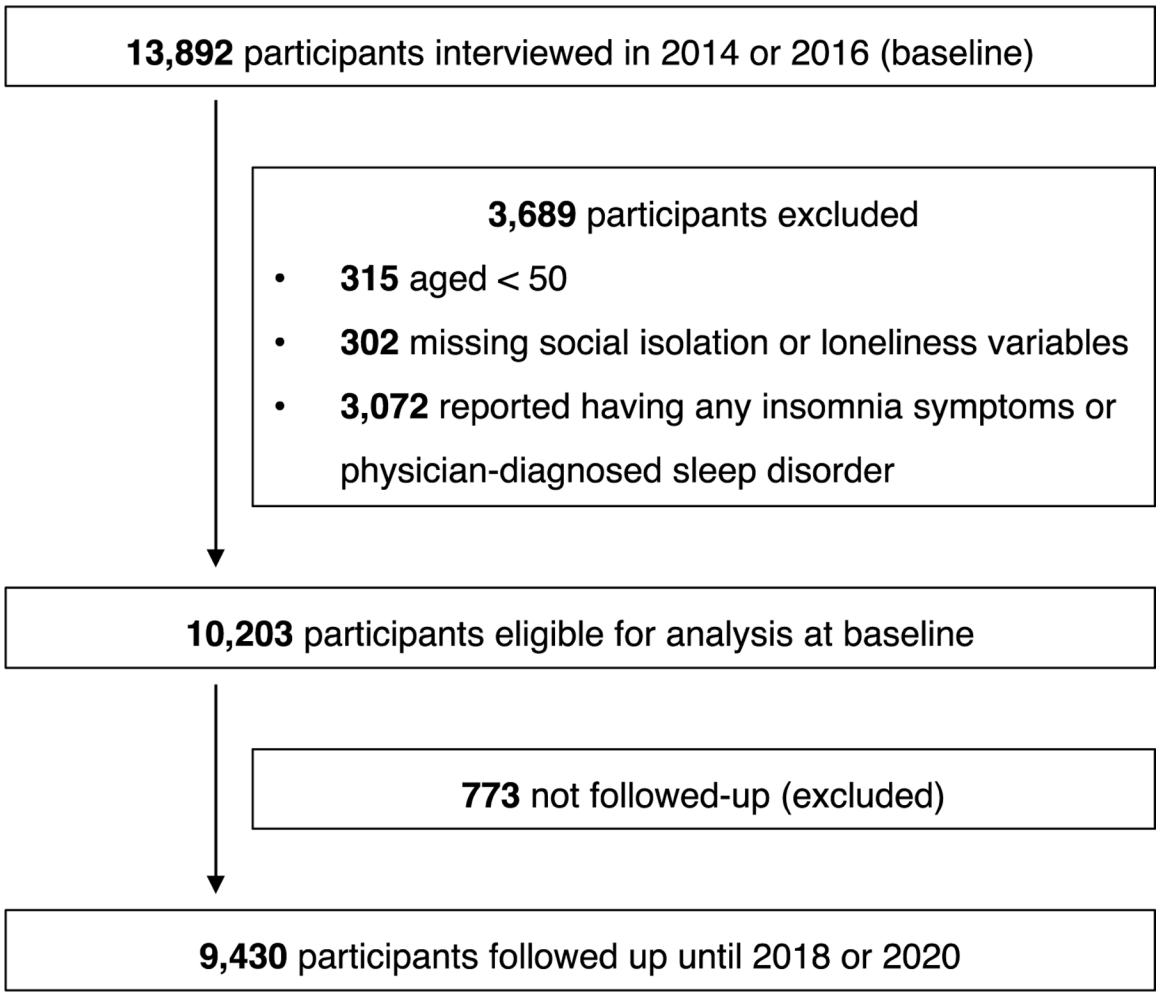

Figure 1. Flowchart of the sample selection.

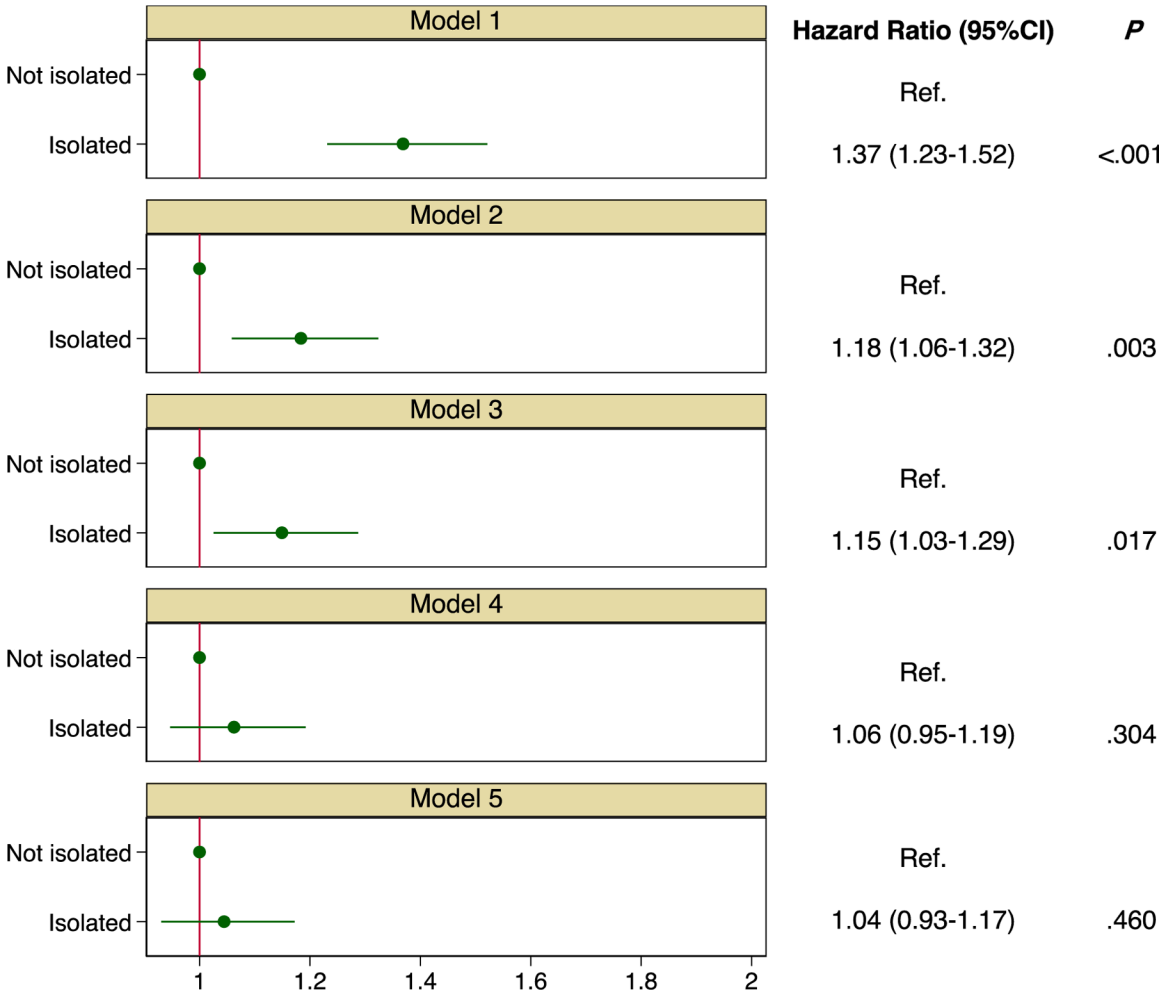

Figure 2. The associations of social isolation with developing any insomnia symptoms (N = 9,430).

Notes:

All hazard ratios (HRs) are weighted to account for the complex survey design. 95% CI, 95% confidence interval. Model 1: Unadjusted. Model 2: Adjusting for age, sex, race/ethnicity, education, and income. Model 3: Additionally adjusting for smoking, alcohol consumption, and physical exercise. Model 4: Additionally adjusting for obesity, depressive symptoms, activities of daily living, cognitive function, and chronic conditions. Model 5: Additionally adjusting for loneliness.

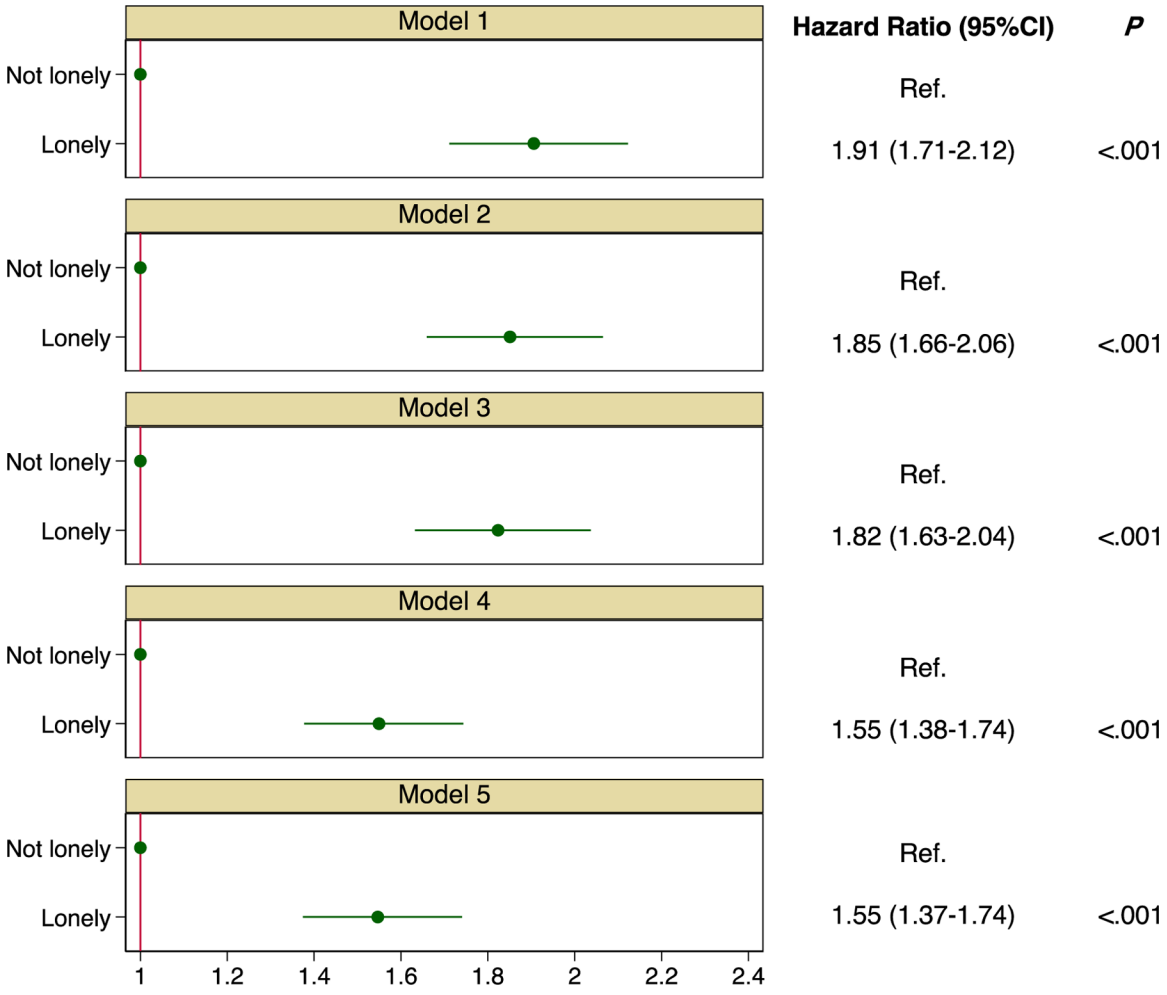

Figure 3. The associations of loneliness with developing any insomnia symptoms (N = 9,430).

Notes:

All hazard ratios (HRs) are weighted to account for the complex survey design. 95% CI, 95% confidence interval. Model 1: Unadjusted. Model 2: Adjusting for age, sex, race/ethnicity, education, and income. Model 3: Additionally adjusting for smoking, alcohol consumption, and physical exercise. Model 4: Additionally adjusting for obesity, depressive symptoms, activities of daily living, cognitive function, and chronic conditions. Model 5: Additionally adjusting for social isolation.

Table 1.

Baseline participants characteristics according to categories of social isolation and loneliness (N = 9,430)[a].

Characteristics	All participants, mean (SD) or N (%)	Not socially isolated, mean (SD) or N (%)	Socially isolated, mean (SD) or N (%)	*P b*	Not lonely, mean (SD) or N (%)	Lonely, mean (SD) or N (%)	*P b*
N	9,430	6,728 (71.4)	2,702 (28.6)		7,471 (79.2)	1,959 (20.8)	
Age in years	68.0 (10.2)	66.9 (9.9)	70.5 (10.5)	<.001	68.2 (10.2)	67.1 (10.4)	<.001
Women	5,495 (58.3)	4,026 (59.8)	1,469 (54.4)	<.001	4,308 (57.7)	1,187 (60.6)	.019
Race/ethnicity				<.001			<.001
Non-Hispanic white	6,294 (66.8)	4,643 (69.0)	1,651 (61.2)		5,003 (67.0)	1,291 (65.9)	
Non-Hispanic black	1,633 (17.3)	1,067 (15.8)	566 (21.0)		1,239 (16.6)	394 (20.1)	
Hispanics	1,177 (12.5)	784 (11.7)	393 (14.5)		990 (13.3)	187 (9.6)	
Other	320 (3.4)	232 (3.5)	88 (3.3)		234 (3.1)	86 (4.4)	
Education				<.001			.009
<High school	1,477 (15.7)	784 (11.7)	693 (25.6)		1,147 (15.3)	330 (16.8)	
High school diploma	2,901 (30.8)	1,855 (27.5)	1,046 (38.7)		2,255 (30.2)	646 (33.0)	
Some/completed college	3,711 (39.3)	2,948 (43.8)	763 (28.3)		2,986 (40.0)	725 (37.0)	
Graduate degree	1,341 (14.2)	1,141 (17.0)	200 (7.4)		1,083 (14.5)	258 (13.2)	
Income levels ($)				<.001			<.001
≤49,999	4,855 (51.6)	2,965 (44.2)	1,890 (70.1)		3,679 (49.4)	1,176 (60.3)	
50,000–99,999	2,441 (26.0)	1,905 (28.4)	536 (19.9)		2,005 (26.9)	436 (22.3)	
100,000–200,000	1,489 (15.8)	1,277 (19.0)	212 (7.9)		1,252 (16.8)	237 (12.2)	
>200,000	620 (6.6)	563 (8.4)	57 (2.1)		518 (6.9)	102 (5.2)	
Smoking status				<.001			<.001
Never	4,406 (46.9)	3,271 (48.8)	1,125 (41.8)		3,510 (47.2)	886 (45.4)	
Former	3,974 (42.3)	2,817 (42.1)	1,157 (43.0)		3,192 (42.9)	782 (40.0)	
Current	1,020 (10.8)	613 (9.1)	407 (15.2)		735 (9.9)	285 (14.6)	
Alcohol consumption				<.001			<.001
Never	5,532 (58.9)	3,681 (54.9)	1,851 (68.8)		4,291 (57.6)	1,241 (63.6)	
Light	2,818 (30.0)	2,242 (33.4)	576 (21.4)		2,302 (30.9)	516 (26.5)	
Heavy	1,048 (11.1)	784 (11.7)	264 (9.8)		855 (11.5)	193 (9.9)	
Have regular physical exercise	2,572 (27.4)	2,046 (30.5)	526 (19.5)	<.001	2,148 (28.9)	424 (21.7)	<.001
Obesity (BMI ≥30 kg/m^2)	5,948 (63.1)	4,250 (63.2)	1,698 (62.8)	.766	4,766 (63.8)	1,182 (60.3)	.005
Depressive symptoms	.68 (1.24)	.57 (1.13)	.95 (1.44)	<.001	.50 (1.01)	1.35 (1.71)	<.001
Cognitive function	15.22 (4.50)	15.84 (4.33)	13.66 (4.55)	<.001	15.36 (4.44)	14.68 (4.71)	<.001
ADL disability	452 (4.8)	244 (3.6)	208 (7.7)	<.001	316 (4.2)	136 (6.9)	<.001
Number of chronic conditions	1.84 (1.27)	1.73 (1.25)	2.09 (1.27)	<.001	1.81 (1.26)	1.93 (1.29)	<.001

Note:

Abbreviations: SD, standard deviation; BMI, body mass index (kilograms divided by height in meters squared), ADL, activities of daily living.

[a] Unless indicated otherwise, data are expressed as N (%) of participants. Percentages have been rounded and may not total 100, and numbers may not total numbers in column headings owing to missing data.

[b] Comparisons were performed using *t*-tests for continuous variables and the Chi-squared tests for categorical variables.

Table 2.

Hazard ratios (HRs) for the associations of social isolation and loneliness with onset of each specific insomnia symptom (N = 9,430).

	No. of events/No. of participants (%)				No. of events/No. of participants			
Insomnia symptoms	**Socially isolated**	**Not socially isolated**	**HR (95% CI)**	***P***	**Lonely**	**Not lonely**	**HR (95% CI)**	***P***
Difficulty initiating sleep	459/2,702 (17.0)	935/6,728 (13.9)	1.09 (0.98, 1.22)	.103	337/1959 (17.2)	1,057/7,471 (14.1)	1.17 (1.05, 1.32)	<.01
Difficulty maintaining sleep	408/2,702 (15.1)	700/6,728 (10.4)	1.15 (1.01, 1.31)	.038	318/1,959 (16.2)	790/7,471 (10.6)	1.31 (1.14, 1.50)	<.001
Early-morning awakening	492/2,702 (18.2)	841/2,702 (12.5)	1.19 (1.06, 1.34)	.003	398/1,959 (20.3)	935/7,471 (12.5)	1.36 (1.20, 1.53)	<.001
Nonrestorative sleep	438/2,702 (16.2)	787/6,728 (11.7)	1.11 (0.99, 1.26)	.083	388/1,959 (19.8)	837/7,471 (11.2)	1.49 (1.31, 1.69)	<.001

Note:

All hazard ratios (HRs) are weighted to account for the complex survey design. 95% CI, 95% confidence interval. Models adjusted for age, sex, race/ethnicity, education, income, smoking, alcohol consumption, physical exercise, obesity, depressive symptoms, activities of daily living, cognitive function, and chronic conditions.