



## Research article

## What types of insomnia relate to anxiety and depressive symptoms in late life?

Courtney J. Bolstad<sup>a,\*</sup>, Michael R. Nadorff<sup>a,b</sup><sup>a</sup> Mississippi State University, Mississippi State, USA<sup>b</sup> Department of Psychiatry and Behavioral Sciences, Baylor College of Medicine, Houston, TX, USA

## ARTICLE INFO

## Keywords:

Psychology  
Onset insomnia  
Maintenance insomnia  
Older adults

## ABSTRACT

**Background:** Symptoms of insomnia are associated with symptoms of depression and anxiety in older adults, yet less is known about the relation of specific forms of insomnia (i.e., onset, maintenance, and terminal insomnia) with these symptoms. This study explored how insomnia types related to symptoms of anxiety and depression in older adults. It was hypothesized that onset and maintenance insomnia would have stronger relations to anxiety and depressive symptoms than terminal insomnia.

**Methods:** One-hundred thirty-three older adults (mean age 69, age range 65–89) were recruited using Amazon's Mechanical Turk. Participants completed the Insomnia Severity Index, Geriatric Depression Scale-Short Form, and Geriatric Anxiety Inventory-Short Form.

**Results:** Regression analyses that controlled for the comorbidity between anxiety and depressive symptoms indicated that onset insomnia was the only independent predictor of anxiety symptoms, and maintenance insomnia was the only independent predictor of depressive symptoms, each of which had medium to large effect sizes.

**Limitations:** Our findings are limited by an online, primarily Caucasian, and non-clinical sample as well as the cross-sectional design of the study.

**Conclusions:** Our findings suggest that despite overlap between symptoms of depression and anxiety, insomnia may have different mechanisms of affecting each disorder. Thus, the type of insomnia is clinically relevant and should be assessed when symptoms of anxiety, depression, and/or sleep difficulties are reported.

## 1. Introduction

We spend approximately a third of our lives asleep, which promotes physical, mental, and psychological well-being. Sleep helps to maintain healthy immune system functioning and promotes physiological homeostasis (Aldabal and Bahammam, 2011), and is important for the consolidation of memories, thus aiding in learning (Maquet, 2001). Sleep can also improve attention, decision-making, and problem-solving abilities (Alhola and Polo-Kantola, 2007; Linde and Bergströme, 1992). Getting enough sleep also helps to improve one's ability to regulate emotions and may lead to more positive moods (Kahn et al., 2013).

## 1.1. Sleep and insomnia in older adults

Changes in sleep are common as we age. To begin, total sleep time (TST) decreases by approximately 10 minutes per decade of age (Dorffner

et al., 2015; Ohayon and Roth, 2003). It has also been found that sleep efficiency (i.e., ratio of time asleep to time in bed) decreases with age (Li et al., 2018a; Ohayon and Roth, 2003), and this may be associated with increased sleep latency (i.e., time to initially fall asleep) and waking after sleep onset. Additionally, older adults have lighter sleep, as the time spent in Stage 1 and Stage 2 slow wave sleep increases and the time spent in stage 3 slow wave sleep decreases with age (Li et al., 2018; Ohayon and Roth, 2003). This is especially problematic as older adults often deal with health conditions such as sleep apnea, nocturia, and chronic pain which, when combined with lighter sleep, can result in more arousals.

Unsurprisingly given these changes in sleep architecture, the prevalence of insomnia symptoms increases across the lifespan. Ohayon and Roth (2003) found that 24% of people over the age of 65 reported insomnia symptoms, and people over 65 were more likely to endorse persistent insomnia present for more than five years compared to their younger counterparts. Examining the prevalence of the three insomnia

\* Corresponding author.

E-mail address: [cjb905@msstate.edu](mailto:cjb905@msstate.edu) (C.J. Bolstad).<https://doi.org/10.1016/j.heliyon.2020.e05315>

Received 19 May 2020; Received in revised form 12 September 2020; Accepted 16 October 2020

2405-8440/© 2020 The Author(s). Published by Elsevier Ltd. This is an open access article under the CC BY-NC-ND license (<http://creativecommons.org/licenses/by-nc-nd/4.0/>).

types in later life, [Ohayon and Roth \(2001\)](#) found that participants over age 65 had higher rates of onset and maintenance insomnia than participants younger than 45, whereas rates of terminal insomnia were comparable across the lifespan. It is possible that rates of terminal insomnia are higher for older adults, but they may change what they view as an acceptable and normative wake time, thus reporting similar rates of terminal insomnia as their younger counterparts.

### 1.2. Insomnia's relation with depression and anxiety

Insomnia often co-occurs with depression and anxiety disorders ([Ohayon and Roth, 2003](#)), and in fact insomnia is a DSM-5 criterion for both major depressive disorder (MDD) and generalized anxiety disorder (GAD; [American Psychiatric Association, 2013](#)). [Perlis et al. \(2006\)](#) found that insomnia was a significant risk factor for the later development of MDD such that participants with insomnia were six times more likely to obtain an MDD diagnosis at follow-up than participants without insomnia. They also found that maintenance insomnia was significantly associated with later MDD diagnosis compared to onset and terminal insomnia. Meta-analytic findings also have shown that individuals with insomnia are twice as likely to develop depression than individuals without insomnia ([Baglioni et al., 2011](#)), and this rate may increase to 4- to 5-time greater likelihood of developing depression in adolescents ([Sivertsen et al., 2014](#)). Insomnia also may be a perpetuating factor for depression in older adults ([Pigeon et al., 2008](#)). Research on adolescent depression and insomnia suggests that this is not a bidirectional relation, but rather insomnia is a precursor to depression ([Lovato and Gradisar, 2014](#)). [Ohayon and Roth \(2003\)](#) found that insomnia more often appeared before mood disorder symptoms compared to concurrently or after mood disorder symptoms. The same effect was not found for anxiety symptoms, as insomnia more often appeared after anxiety symptoms than concurrently or before anxiety symptoms. Similar results were found in an adolescent sample as anxiety preceded insomnia in 73% of cases whereas insomnia preceded depression in 69% of cases ([Johnson et al., 2006](#)).

Insomnia is associated with depression and anxiety in older adults, yet less is known about how specific forms of insomnia are related to anxiety and depressive symptoms. Recent research has explored the relation between onset insomnia and anxiety in non-older adult samples. For example, [Kalmbach et al. \(2019\)](#) found that medical interns with onset insomnia prior to internship were at an increased risk of later developing GAD during their internship year. [Bragantini et al. \(2019\)](#) found that anxiety symptoms were most prevalent in individuals with onset insomnia, and 91% of individuals with severe anxiety reported onset insomnia alone or in addition to another insomnia symptom. As for the relation between types of insomnia and depressive symptoms, [Suzuki et al. \(2009\)](#) found that maintenance insomnia was significantly correlated with depressive symptoms in a sample of individuals with Parkinson's disease, whereas onset insomnia was not. The present study attempted to expand upon these findings to further explore the relation between types of insomnia and anxiety and depressive symptoms in a sample of older adults.

For the purposes of this study, we defined insomnia using the DSM-5 criteria ([American Psychiatric Association, 2013](#)) for insomnia disorder, which state that insomnia is characterized by a concern regarding one's quantity or quality of sleep related to difficulty initiating sleep (i.e., onset insomnia), maintaining sleep (i.e., maintenance insomnia), and/or early morning awakenings (i.e., terminal insomnia). These problems must cause significant impairment and be present at least three nights a week for three months. They also must occur despite the opportunity to sleep. Of the three types of insomnia, maintenance insomnia has been found to be the most common ([Jaussent et al., 2011](#); [Ohayon and Roth, 2001](#)).

It is important to note the difference between insomnia and TST or sleep deprivation. These terms are commonly used interchangeably; however, TST and sleep deprivation refer only to the total number of

hours of sleep on a given night. However, insomnia refers to the lack of sleep when provided the opportunity to sleep. For example, someone who works long hours in addition to other life demands may only have a four-hour window to sleep, and they may achieve four hours of consistent sleep a night (i.e., TST = 4 h), which is sleep deprivation ([Watson et al., 2015](#)). On the other hand, someone with insomnia may be provided a ten-hour period when they can sleep, but they have difficulty falling asleep or staying asleep. They may only obtain seven hours, which is considered an optimal amount of sleep. Therefore, someone with insomnia may have a low TST and experience sleep deprivation, although this is not always the case ([Perlis et al., 2005](#)).

### 1.3. Hypotheses

It was hypothesized that onset and maintenance insomnia would have stronger relations to anxiety and depressive symptoms than terminal insomnia. These hypotheses are based upon the recent work of [Kalmbach et al. \(2019\)](#) and [Bragantini et al. \(2019\)](#) outlined above. Their studies suggest that anxiety symptoms are associated more with onset insomnia than other forms of insomnia. This is further supported by findings that worry and rumination are significantly related to onset and maintenance insomnia ([Galbiati et al., 2018](#)). Additionally, catastrophizing worry and rumination has been found to significantly contribute to onset insomnia in an adolescent sample ([Hiller et al., 2014](#)). Therefore, the worry associated with anxiety disorders may cause a delay in sleep initiation.

As for depression, maintenance insomnia is likely to have a more significant relation to depressive symptoms than onset or terminal insomnia ([Perlis et al., 2006](#); [Suzuki et al., 2009](#)). This may occur due to individuals with depressive symptoms being less active throughout the day and/or napping, which may lead to lighter sleep at night due to a decreased homeostatic sleep drive and a dampened circadian rhythm amplitude ([Hori et al., 2016](#)). This hypothesis is supported by a recent meta-analysis of actigraphy data which found that depressed individuals were less active during the day and had longer awakenings in the middle of the night, but not a longer sleep latency, than healthy controls ([Tazawa et al., 2019](#)). Further, maintenance insomnia has been found to improve after an Internet-provided treatment for depression, whereas onset and terminal insomnia were not significantly changed ([Mullarkey et al., 2020](#)).

Finally, terminal insomnia was not hypothesized to be related to symptoms of anxiety or depression as older adults may find waking early to be normative for their age and thus may not consider terminal insomnia to be problematic. This has yet to be examined, however, and thus should be considered exploratory.

## 2. Methods

### 2.1. Participants and procedure

The current study was a secondary analysis of a dataset that was collected to examine the relation between sleep, mood, and activities of daily living which was approved by the Mississippi State University Institutional Review Board ([Webb et al., 2018](#)). A sample of 133 older adults were collected as it was sufficient to detect medium-sized effects in our target relations. Participants were recruited using Amazon's Mechanical Turk (MTurk), which is an online crowdsourcing platform that hosts human-intelligence tasks (HITs) for users to complete for compensation. MTurk is a commonly used source for sampling participants in psychological research as it often approximates clinical samples ([Mason and Suri, 2012](#); [Shapiro et al., 2013](#)). Further, MTurk is often used to recruit older adult participants, although samples of older adults drawn from MTurk have been found to be more likely to be female as well as to have higher cognitive functioning and memory, self-reported physical health, income, education, and depressive symptoms than older adults recruited from the probabilistic, nationwide Health and Retirement Survey (HRS; [Ogletree and Katz, 2020](#)). The present study's

survey was listed on the HITs page, which provided a brief description of the study, qualifications needed (i.e., resident of the United States and age 65 or older), estimated duration of the survey, and compensation provided (\$0.50). Interested MTurk workers could then accept the HIT and complete the survey online. Participants included in the present study were 65–89 years old ( $M = 69.38$ ,  $SD = 4.63$ ). Compared to the demographic composition of U.S. older adults in 2011–2017, the present sample was more likely to be female (63.9% vs. 55.8%), White (87.2% vs. 77%), and less likely to be married (36.1% vs. 55.2%) or widowed (24.1% vs. 26.1%) (Johnson and Appold, 2017; Administration for Community Living, 2018). Approximately half of the sample held at least an associate degree and half had annual income less than \$35,000. Additional participant recruitment methods and procedure are reported elsewhere (Webb et al., 2018).

## 2.2. Measures

Participants completed the Insomnia Severity Index (ISI), and the first three questions from the measure were used to assess participants' severity of onset (i.e., "Difficulty falling asleep"), maintenance (i.e., "Difficulty staying asleep"), and terminal (i.e., "Problems waking up too early") insomnia symptoms individually over the past two weeks. The ISI employs a 5-point scale from 0 or no difficulties to 4 or very severe difficulties (Bastien et al., 2001). Cronbach's alpha for the full seven item measure was acceptable ( $\alpha = 0.90$ ), and since the three items referencing the three insomnia types were entered individually in the analyses in order to explore the relation between each type of insomnia and the outcome variables, internal consistency was not measured for these items.

Depressive symptoms were measured using the Geriatric Depression Scale – Short Form (GDS-SF; Sheikh and Yesavage, 1986). The GDS-SF is a validated 15-item questionnaire comprised of yes/no questions used to screen for depression in older adults. Scores above 5 are suggestive of depression and scores above 10 are highly indicative of depression. This questionnaire asks about energy level but does not ask about sleep problems. Internal consistency of the GDS-SF was acceptable in the present study ( $\alpha = 0.89$ ).

Symptoms of anxiety were measured using the Geriatric Anxiety Index – Short Form (GAI-SF; Byrne and Pachana, 2011). The GAI-SF lists five items pertaining to worries and feeling nervous. Respondents stated whether they agreed or disagreed with each item which provided a score range of 0–5. A score of 3 or higher has been found to be indicative of generalized anxiety disorder. This measure also does not ask about sleep problems. Internal consistency of the GAI-SF was acceptable in the present study ( $\alpha = 0.90$ ).

## 2.3. Data analysis

All analyses were conducted using IBM SPSS Statistics (Version 26). Two hierarchical regressions were used to explore the relation between

insomnia types and anxiety and depressive symptoms. The first model examined the relation between the three types of insomnia and depressive symptoms, while controlling for anxiety symptoms. The first step of the regression included anxiety symptoms; the second step included the onset, maintenance, and terminal insomnia variables; and the third step included age, marital status, and sex as these socio-demographic variables have been found to relate to insomnia and depressive symptoms in older adults (Barua et al., 2010; Chen et al., 2015; Jaussent et al., 2011). Depressive symptoms were entered as the outcome variable. The second model tested the relation between the three types of insomnia and anxiety symptoms, while controlling for depressive symptoms. In this model, depressive symptoms were entered in the first step; onset, maintenance, and terminal insomnia variables were entered in the second step; and age, marital status, and sex were entered in the third step as these socio-demographic variables have been found to relate to insomnia and anxiety symptoms in older adults (Byers et al., 2010; Chen et al., 2015; Gutiérrez-Vega et al., 2018; Jaussent et al., 2011). Anxiety symptoms were entered as the outcome variable.

## 3. Results

On average, this sample had an elevated score on the GDS-SF, such that 42.9% of the sample reported clinically relevant depressive symptoms (i.e., scores above 5; see Table 1). The sample also was elevated on the GAI-SF. Although the average did not meet the GAI-SF cut off score of 3, 51% of the sample scored at or above 3. Overall, the sample reported mild difficulty with each of the insomnia types. Anxiety symptoms, depressive symptoms, and the three types of insomnia were all weakly to moderately positively correlated at  $p < .01$ . As for the demographic variables, only marital status was weakly correlated with depressive symptoms. Descriptive statistics and correlations are depicted in Table 1.

### 3.1. Insomnia types and depressive symptoms

In the model with depressive symptoms as the dependent variable, anxiety symptoms accounted for 37% of the variability of depressive symptoms in the first step ( $p < .001$ ). Adding insomnia symptoms in step two accounted for approximately 6% additional variance in depressive symptoms ( $p < .01$ ). Specifically, maintenance insomnia was the only form of insomnia that had a significant relation to depressive symptoms, independent of anxiety symptoms and other forms of insomnia ( $p < .01$ ). As maintenance insomnia severity increased by one point, depressive symptoms increased by approximately one point, which was a medium to large effect (i.e., semi-partial correlation = 0.20). Entering demographic covariates (i.e., age, gender, and marital status) in the third step resulted in approximately a 3% increase in variance, though this was not significant. When these covariates were considered, the relation between maintenance insomnia and depressive symptoms remained significant ( $p < .05$ ). These results are shown in Table 2.

**Table 1.** Descriptive statistics and correlations of predictor and outcome variables.

Variable	Clinical %	M	SD	1	2	3	4	5	6	7	8
1. GDS-SF	42.9%	5.51	4.50	-	-	-	-	-	-	-	-
2. GAI-SF	51.1%	2.43	2.12	.60***	-	-	-	-	-	-	-
3. Onset	-	1.49	1.07	.37***	.45***	-	-	-	-	-	-
4. Main.	-	1.70	1.06	.44***	.37***	.53***	-	-	-	-	-
5. Terminal	-	1.33	1.17	.25**	.25**	.30***	.38***	-	-	-	-
6. Age	-	69.57	5.08	.04	.12	.02	.00	.07	-	-	-
7. Gender	-	-	-	-.05	.07	.08	.05	-.08	-.06	-	-
8. Marital	-	-	-	.18*	.00	.08	.16	-.01	-.03	.12	-

Note.  $N = 133$ . GDS-SF = Geriatric Depression Scale – Short Form, GAI-SF = Geriatric Anxiety Inventory – Short Form, Main. = Maintenance insomnia, no clinical cut off score has been determined for the ISI items (i.e., 3, 4, 5), \* $p < .05$ . \*\* $p < .01$ . \*\*\* $p < .001$ , two-tailed.

**Table 2.** Summary of hierarchical regression analysis predicting depressive symptoms.

Variable	Step 1			Step 2			Step 3		
	B	$\beta$	sr	B	$\beta$	sr	B	$\beta$	sr
GAI-SF	1.29	0.60***	0.60	1.07	0.50***	0.44	1.12	0.53***	0.45
Onset				0.30	0.01	0.01	0.30	0.01	0.01
Main.				1.03	0.24**	0.20	0.92	0.22*	0.17
Terminal				0.11	0.03	0.03	0.10	0.03	0.02
Age							-0.02	-0.02	-0.02
Gender							-1.06	-0.11	-0.11
Marital							0.36	0.15*	0.15
R <sup>2</sup>		0.37			0.42			0.45	
$\Delta R^2$		0.37			0.06			0.03	
F for $\Delta R^2$		75.31***			4.19**			2.44	

Note.  $N = 133$ .  $sr$  = semi-partial correlation, GAI-SF = Geriatric Anxiety Inventory – Short Form, Main. = Maintenance insomnia, Marital = Marital status, \* $p < .05$ . \*\* $p < .01$ . \*\*\* $p < .001$ .

### 3.2. Insomnia types and anxiety symptoms

In the model with anxiety symptoms as the dependent variable, depressive symptoms accounted for 37% of the variability of anxiety symptoms in step one ( $p < .001$ ). Adding insomnia symptoms in step two accounted for approximately 6% more of the variability of anxiety symptoms ( $p < .01$ ). Specifically, onset insomnia was the only form of insomnia that had a significant relation to anxiety symptoms independent of depressive symptoms and other forms of insomnia ( $p < .01$ ). As onset insomnia severity increased by one point, anxiety symptoms increased by half a point, which was a medium to large effect (i.e., semi-partial correlation = 0.21). When accounting for the demographic covariates in the third step, approximately 3% more variance in anxiety symptoms was accounted for, though this was not significant. Onset insomnia remained to have significant relation with anxiety symptoms at this step ( $p < .01$ ). These results are shown in Table 3.

## 4. Discussion

Consistent with the hypotheses, a regression analysis accounting for anxiety symptoms indicated that maintenance insomnia was the only form of insomnia to have a significant independent positive relation to depressive symptoms. Further, this relation remained after sex, age, and marital status were considered. Additionally, it was found that onset insomnia was the only form of insomnia to have a significant independent positive relation to anxiety symptoms when accounting for depressive symptoms. Again, this finding remained even after

considering sex, age, and marital status. Each of these relations had a medium to large effect size.

These results shed light on the association between symptoms of anxiety, depression, and insomnia among older adults, showing that a different form of insomnia is uniquely associated with both anxiety and depressive symptoms. This is an interesting finding and may suggest that, despite their similarities, there may be mechanistic differences in the association between symptoms of anxiety, depression, and sleep difficulties. Alternatively, it is also possible that insomnia may be a bridge between symptoms of anxiety and depression such that anxiety symptoms cause onset insomnia, which leads to maintenance insomnia, which further leads to depressive symptoms. Previous research has proposed that onset insomnia may provide a “gateway” to the more common and enduring maintenance insomnia (Pillai et al., 2015). Additionally, meta-analytic research on adolescent insomnia suggests that insomnia is a precursor to depressive symptoms, and not vice versa (Lovato and Gradisar, 2014). Recent research on adolescents has confirmed a pathway from anxiety to depression through insomnia (Li et al., 2018b), although this study grouped types of insomnia together. Longitudinal research that examines the mechanistic progression of these disorders would greatly increase understanding of why certain sleep problems are associated with symptoms of depression and anxiety.

The finding that onset insomnia and anxiety symptoms were significantly related was not surprising. Rumination and worry are common symptoms of anxiety, and these cognitions may cause difficulty falling asleep (Gabiati et al., 2018; Hiller et al., 2014), potentially through arousal of the sympathetic nervous system (Ottaviani, 2018).

**Table 3.** Summary of hierarchical regression analysis predicting anxiety symptoms.

Variable	Step 1			Step 2			Step 3		
	B	$\beta$	sr	B	$\beta$	sr	B	$\beta$	sr
GDS-SF	0.28	0.60***	0.60	0.24	0.50***	0.44	0.25	0.52***	0.45
Onset				0.50	0.25**	0.21	0.48	0.24**	0.20
Main.				-0.01	0.00	0.00	0.02	0.01	0.01
Terminal				0.09	0.05	0.05	0.09	0.05	0.04
Age							0.05	0.10	0.10
Gender							0.42	0.10	0.09
Marital							-0.14	-0.13	-0.12
R <sup>2</sup>		0.37			0.43			0.46	
$\Delta R^2$		0.37			0.06			0.03	
F for $\Delta R^2$		75.31***			4.66**			2.41	

Note.  $N = 133$ .  $sr$  = semi-partial correlation, GDS-SF = Geriatric Depression Scale – Short Form, Main. = Maintenance insomnia, Marital = Marital status, \* $p < .05$ . \*\* $p < .01$ . \*\*\* $p < .001$ .

Given that past literature has shown that poor sleep negatively affects depression treatment among older adults (Dew et al., 1997) and that adding sleep treatment improves depression treatment in those who have both disorders (Manber et al., 2008), the present findings have the potential to impact the way we assess and treat depression. There is a need for follow-up studies examining whether assessing and targeting these specific forms of insomnia results in even better treatment outcomes for older adults.

#### 4.1. Limitations

Although the present study further elucidates the relation between types of insomnia, anxiety, and depressive symptoms in older adulthood, it is not without limitations. Our sample was recruited using MTurk, which has been found to lead to older adult samples that are more likely to be over-representative of Whites and females, as well as higher in self-reported health, income, education, depressive symptoms, and cognitive functioning than national, probabilistic, in-person samples (e.g., HRS; Ogletree and Katz, 2020). Therefore, it is important to not overgeneralize the present findings to specific groups of older adults (e.g., racial/ethnic minorities), though because few exclusion criteria were used and participants were sampled nationwide, the results are broadly generalizable. Further, the increased rate of depressive symptoms reported by older adult MTurk users may be seen as a strength of this study, since depressive symptoms was one of the primary outcome variables. This suggests that the present findings may generalize to clinical samples more readily than a sample such as the HRS. Although it is also important to note that the measures used in the present study were self-report forms and no clinical diagnoses were made. Additionally, the findings are limited by a lack of data on several potential confounding variables including somatic comorbidities, medication usage, and residential location (e.g., community housing or institution). Finally, temporal or causal conclusions cannot be drawn from these results as this research was cross-sectional. Therefore, although the present study is a meaningful initial step, these findings should be replicated longitudinally in a diverse, clinical sample.

#### 4.2. Conclusion

The present study's findings suggest that despite overlap between anxiety and depressive symptoms, insomnia may have different mechanisms of affecting each disorder in late life. The findings also support that insomnia is not solely a symptom of anxiety or depression, but is a disorder in and of itself, which also comes in unique forms which may differentially affect anxiety and depressive symptoms. New research that recognizes the distinctiveness of the three types of insomnia and explores the role of each individual type of insomnia, rather than grouping the types under one insomnia umbrella, is warranted based upon this study and would be a meaningful addition to the literature.

#### Declarations

##### Author contribution statement

C. J. Bolstad: Conceived and designed the experiments; Analyzed and interpreted the data; Wrote the paper.

M. J. Nadorff - Conceived and designed the experiments; Performed the experiments; Analyzed and interpreted the data; Wrote the paper.

##### Funding statement

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

##### Competing interest statement

The authors declare no conflict of interest.

##### Additional information

Supplementary content related to this article has been published online at <https://doi.org/10.1016/j.heliyon.2020.e05315>.

##### Acknowledgements

We thank Anisha Thomas, M.A., for her direction and support on portions of this work presented at the 2019 Gerontological Society of America's 74<sup>th</sup> annual meeting. Data, analytic methods, and study materials will be made available to other researchers. Individuals interested in obtaining these items may contact the corresponding author via email for access. This work was not preregistered.

##### References

- Administration for Community Living, 2018. A Profile of Older Americans: 2017, pp. 1–16. [https://acl.gov/sites/default/files/Aging and Disability in America/2017OlderAmericansProfile.pdf](https://acl.gov/sites/default/files/Aging%20and%20Disability%20in%20America/2017OlderAmericansProfile.pdf).
- Aldabal, L., Bahammam, A.S., 2011. Metabolic, endocrine, and immune consequences of sleep deprivation. *Open Respir. Med. J.* 5, 31–43.
- Alhola, P., Polo-Kantola, P., 2007. Sleep deprivation: impact on cognitive performance. *Neuropsychiatric Dis. Treat.* 3 (5), 553–567.
- American Psychiatric Association, 2013. *Diagnostic and Statistical Manual of Mental Disorders*, fifth ed. Washington, DC.
- Baglioni, C., Battagliese, G., Feige, B., Spiegelhalter, K., Nissen, C., Voderholzer, U., Lombardo, C., Riemann, D., 2011. Insomnia as a predictor of depression: a meta-analytic evaluation of longitudinal epidemiological studies. *J. Affect. Disord.* 135, 10–19.
- Barua, A., Ghosh, M.K., Kar, N., Basilio, M.A., 2010. Socio-demographic factors of geriatric depression. *Indian J. Psychol. Med.* 32 (2), 87–92.
- Bastien, C.H., Vallières, A., Morin, C.M., 2001. Validation of the Insomnia Severity Index (ISI) as an outcome measure for insomnia research. *Sleep Med.* 2 (4), 297–307.
- Bragantini, D., Sivertsen, B., Gehrman, P., Lydersen, S., Güzey, I.C., 2019. Differences in anxiety levels among symptoms of insomnia. *The HUNT study. Sleep Health* 5 (4), 370–375.
- Byers, A.L., Yaffe, K., Covinsky, K.E., Friedman, M.B., Bruce, M.L., 2010. High occurrence of mood and anxiety disorders among older adults. *Arch. Gen. Psychiatr.* 67 (5), 489.
- Byrne, G.J., Pachana, N.A., 2011. Development and validation of a short form of the geriatric anxiety inventory - the GAI-SF. *Int. Psychogeriatr.* 23 (1), 125–131.
- Chen, J.-H., Waite, L.J., Lauderdale, D.S., 2015. Marriage, relationship quality, and sleep among U.S. older adults. *J. Health Soc. Behav.* 56 (3), 356–377.
- Dew, M.A., Reynolds 3rd, C.F., Houck, P.R., Hall, M., Buysse, D.J., Frank, E., Kupfer, D.J., 1997. Temporal profiles of the course of depression during treatment. Predictors of path-ways toward recovery in the elderly. *Arch. Gen. Psychiatr.* 54 (11), 1016–1024.
- Dorffner, G., Vittr, M., Anderer, P., 2015. The effects of aging on sleep architecture in healthy subjects. *Adv. Exp. Med. Biol.* 821, 93–100.
- Galbiati, A., Giora, E., Sarasso, S., Zucconi, M., Ferini-Strambi, L., 2018. Repetitive thought is associated with both subjectively and objectively recorded polysomnographic indices of disrupted sleep in insomnia disorder. *Sleep Med.* 45, 55–61.
- Gutiérrez-Vega, M., Esparza-Del Villar, O.A., Carrillo-Saucedo, I.C., Montañez-Alvarado, P., 2018. The possible protective effect of marital status in quality of life among elders in a U.S.-Mexico border city. *Community Ment. Health J.* 54 (4), 480–484.
- Hiller, R.M., Lovato, N., Gradisar, M., Oliver, M., Slater, A., 2014. Trying to fall asleep while catastrophising: what sleep-disordered adolescents think and feel. *Sleep Med.* 15 (1), 96–103.
- Hori, H., Koga, N., Hidese, S., Nagashima, A., Kim, Y., Higuchi, T., Kunugi, H., 2016. 24-h activity rhythm and sleep in depressed outpatients. *J. Psychiatr. Res.* 77, 27–34.
- IBM Corp, 2019. IBM SPSS Statistics for Windows, Version 26.0. IBM Corp, Armonk, NY.
- Jausset, I., Dauvilliers, Y., Ancelin, M.L., Dartigues, J.F., Tavernier, B., Touchon, J., Ritchie, K., Besset, A., 2011. Insomnia symptoms in older adults: associated factors and gender differences. *Am. J. Geriatr. Psychiatr.* 19 (1), 88–97.
- Johnson, E.O., Roth, T., Breslau, N., 2006. The association of insomnia with anxiety disorders and depression: exploration of the direction of risk. *J. Psychiatr. Res.* 40 (8), 700–708.
- Johnson, J.H., Appold, S.J., 2017. U.S. Older Adults: Demographics, Living Arrangements, and Barriers to Aging in Place. [https://www.kenaninstitute.unc.edu/wp-content/uploads/2017/06/AgingInPlace\\_06092017.pdf](https://www.kenaninstitute.unc.edu/wp-content/uploads/2017/06/AgingInPlace_06092017.pdf).
- Kahn, M., Sheppes, G., Sadeh, A., 2013. Sleep and emotions: bidirectional links and underlying mechanisms. *Int. J. Psychophysiol.* 89 (2), 218–228.
- Kalmbach, D.A., Abelson, J.L., Arnedt, J.T., Zhao, Z., Schubert, J.R., Sen, S., 2019. Insomnia symptoms and short sleep predict anxiety and worry in response to stress exposure: a prospective cohort study of medical interns. *Sleep Med.* 55, 40–47.

- Li, J., Vitiello, M.V., Gooneratne, N.S., 2018a. Sleep in normal aging. *Sleep Med. Clin.* 13 (1), 1–11.
- Li, Y.L., Starr, L.R., Wray-Lake, L., 2018b. Insomnia mediates the longitudinal relationship between anxiety and depressive symptoms in a nationally representative sample of adolescents. *Depress. Anxiety* 35 (6), 583–591.
- Linde, L., Bergströme, M., 1992. The effect of one night without sleep on problem-solving and immediate recall. *Psychol. Res.* 54 (2), 127–136.
- Lovato, N., Gradisar, M., 2014. A meta-analysis and model of the relationship between sleep and depression in adolescents: recommendations for future research and clinical practice. *Sleep Med. Rev.* 18, 521–529.
- Manber, R., Edinger, J.D., Gress, J.L., San Pedro-Salcedo, M.G., Kuo, T.F., Kalista, T., 2008. Cognitive behavioral therapy for insomnia enhances depression outcome in patients with comorbid major depressive disorder and insomnia. *Sleep* 31 (4), 489–495.
- Maquet, P., 2001. The role of sleep in learning and memory. *Science* 294, 1048–1052.
- Mason, W., Suri, S., 2012. Conducting behavioral research on Amazon's Mechanical Turk. *Behav. Res. Methods* 44 (1), 1–23.
- Mullarkey, M.C., Stein, A.T., Pearson, R., Beavers, C.G., 2020. Network analyses reveal which symptoms improve (or not) following an Internet intervention (Deprexis) for depression. *Depress. Anxiety* 37 (2), 115–124.
- Ogletree, A.M., Katz, B., 2020. How do older adults recruited using MTurk differ from those in a national probability sample? *Int. J. Aging Hum. Dev.*
- Ohayon, M.M., Roth, T., 2001. What are the contributing factors for insomnia in the general population? *J. Psychosom. Res.* 51 (6), 745–755.
- Ohayon, M.M., Roth, T., 2003. Place of chronic insomnia in the course of depressive and anxiety disorders. *J. Psychiatr. Res.* 37 (1), 9–15.
- Ottaviani, C., 2018. Brain-heart interaction in perseverative cognition. *Psychophysiology* 55 (7), 1–14.
- Perlis, M.L., Jungquist, C., Smith, M.T., Posner, D., 2005. *Cognitive Behavioral Treatment of Insomnia: A Session-By-Session Guide*. Springer Science+Business Media, LLC.
- Perlis, M.L., Smith, L.J., Lyness, J.M., Matteson, S.R., Pigeon, W.R., Jungquist, C.R., Tu, X., 2006. Insomnia as a risk factor for onset of depression in the elderly. *Behav. Sleep Med.* 4 (2), 104–113.
- Pigeon, W.R., Hegel, M., Unützer, J., Fan, M.Y., Sateia, M.J., Lyness, J.M., Phillips, C., Perlis, M.L., 2008. Is insomnia a perpetuating factor for late-life depression in the IMPACT cohort? *Sleep* 31 (4), 481–488.
- Pillai, V., Roth, T., Drake, C.L., 2015. The nature of stable insomnia phenotypes. *Sleep* 38 (1), 127–138.
- Shapiro, D.N., Chandler, J., Mueller, P.A., 2013. Using Mechanical Turk to study clinical populations. *Clin. Psychol. Sci.* 1 (2), 213–220.
- Sheikh, J.I., Yesavage, J.A., 1986. Geriatric Depression Scale (GDS) recent evidence and development of a shorter version. *Clin. Gerontol.* 5 (1–2), 165–173.
- Sivertsen, B., Harvey, A.G., Lundervold, A.J., Hysing, M., 2014. Sleep problems and depression in adolescence: results from a large population-based study of Norwegian adolescents aged 16–18 years. *Eur. Child Adolesc. Psychiatr.* 23, 681–689.
- Suzuki, K., Miyamoto, M., Miyamoto, T., Okuma, Y., Hattori, N., Kamei, S., Yoshii, F., Utsumi, H., Iwasaki, Y., Iijima, M., Hirata, K., 2009. Correlation between depressive symptoms and nocturnal disturbances in Japanese patients with Parkinson's disease. *Park. Relat. Disord.* 15 (1), 15–19.
- Tazawa, Y., Wada, M., Mitsukura, Y., Takamiya, A., Kitazawa, M., Yoshimura, M., Mimura, M., Kishimoto, T., 2019. Actigraphy for evaluation of mood disorders: a systematic review and meta-analysis. *J. Affect. Disord.* 253, 257–269.
- Watson, N.F., Badr, M.S., Belenky, G., Bliwise, D.L., Buxton, O.M., Buysse, D., Dinges, D.F., Gangwisch, J., Grandner, M.A., Kushida, C., Malhotra, R.K., Martin, J.L., Patel, S.R., Quan, S., Tasali, E., 2015. Recommended amount of sleep for a healthy adult: a joint consensus statement of the American Academy of Sleep Medicine and Sleep Research Society. *Sleep* 38 (6), 843–844.
- Webb, C.A., Cui, R., Titus, C., Fiske, A., Nadorff, M.R., 2018. Sleep disturbance, activities of daily living, and depressive symptoms among older adults. *Clin. Gerontol.* 41 (2), 172–180.