Current Geriatrics Reports (2019) 8:271–290
https://doi.org/10.1007/s13670-019-00300-x

NURSING (R D'AOUST, SECTION EDITOR)

Insomnia in Older Adults

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Published online: 22 October 2019

Abstract

Purpose of Review To evaluate and summarize recent research articles pertaining to insomnia in older adults that can guide healthcare providers on factors to consider when assessing and managing insomnia.

Recent Findings Up to 75% of older adults experience symptoms of insomnia. Insomnia is associated with socioeconomic status, racial and ethnic classification, family relationships, medical and mental health disorders, cognitive function, and dementia. Although one-fifth of older adults are still prescribed sleep medications, cognitive behavioral therapy for insomnia is the first-line treatment for insomnia and has resulted in short-term and long-term benefits for older adults.

Summary To manage insomnia safely and effectively, healthcare providers need to consistently assess for insomnia during baseline and annual assessments, evaluate medical and social factors associated with insomnia, minimize the use of sleep medications, and provide referrals to and/or collaborate with providers who perform cognitive behavioral therapy for insomnia. Insomnia screening is important as it facilitates early intervention, reduces the potential for pharmacological management, and enables further assessment and early identification of associated outcomes, such as cognitive impairment.

Keywords Early morning awakenings · Cognitive behavioral therapy for insomnia · Cognitive decline · Walking · Socioeconomic status

Introduction

Insomnia is one of the most common sleep disorders in older adults. It is defined as complaints of difficulty initiating sleep, difficulty maintaining sleep, or early morning awakenings with the inability to return to sleep in the presence of adequate sleep opportunity or ideal environmental factors; and is accompanied by daytime clinical distress or functional impairment [1, 2]. Based on the fifth edition of the *Diagnostic and Statistical Manual for Mental Disorders,* the symptoms occur at least three nights a week for at least 3 months [1]. Insomnia may also be episodic if the symptoms recur and persist for several weeks at a time, over several years.

Up to 75% of older adults report insomnia symptoms [3–8]. The homeostatic and circadian mechanisms that drive the sleep and wake cycles diminish with age, thus, reducing the drive to sleep and increasing the risk for insomnia [9]. For example, older adults report an increase in wake time after initially falling asleep and early morning awakenings [9, 10]. Due to poor sleep efficiency, older adults experience daytime sleepiness and fatigue and tend to nap during the day [9, 10]. After retirement, many older adults no longer have fixed work schedules, which may also increase the risk of insomnia. Many other factors, such as reduced mobility, reduced participation in social activities, decreased social interaction, and increased caregiving responsibilities, are prevalent in the older adult population and increase the risk for insomnia [9].

Older adults with severe insomnia report a higher number of comorbid illnesses than those without insomnia [11]. Insomnia is associated with multiple medical and mental health problems, including an increased risk for psychiatric disorders, suicide, and chronic health conditions, such as obesity, diabetes, cardiovascular disease, and chronic pain [12••],

This article is part of the Topical Collection on *Nursing*

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which leads to increased medication consumption [7]. Treating insomnia is vital because it has the potential to reduce public health burden [11]. The aim of this paper is to evaluate and summarize recent research articles pertaining to insomnia in older adults to guide healthcare providers on factors to consider during assessment and management of insomnia.

Method

Search terms used in PubMed were "insomnia" (title/abstract) AND "older adult". The filters were "humans" and "aged 65+ years." We found 76 studies from 1/1/16 through 4/4/2019. We excluded literature reviews, clinical guideline reviews, and studies with participants who had human immunodeficiency virus, hepatitis, cancer, sickle cell disease, internet addiction disorders, and schizophrenia. After reviewing the abstracts, we included 48 studies (see Table 1). Twelve studies included middle-aged participants and one study each included older adults with osteoarthritis, chronic pain, general anxiety disorder, and major depressive disorder. Two coauthors evaluated the methodological quality of the studies using a validated scoring system for rating empirical studies with different methodologies [13]. A total of nine study components were rated a quality score ranging from 1 (very poor) to 4 (good), with a maximum potential score of 36 for each study. The studies in this review varied in overall quality, with scores ranging from 25 to 36 and an average score of 30.6, meaning that the majority of the studies were of fair to good quality (Table 1).

Results

Prevalence of Insomnia

In studies that utilized the diagnostic criteria for insomnia disorder, the prevalence of insomnia ranged from 17 to 60% [14–16]. Gehrman and colleagues [17] reported that approximately 14% of the older adults in their sample (n = 291) had moderate insomnia and 2.7% had severe insomnia. In studies that asked about insomnia symptoms, the prevalence of insomnia ranged from 8.2 to 74.8% [3–5, 8, 18–20, 21•, 22–24]. The most common sleep complaints included difficulty maintaining sleep (range, 13.1 to 40.7%), difficulty initiating sleep (range, 10.3 to 55.6%), and early morning awakenings (range, 10.7 to 37.2%) [3, 5, 7, 8].

Eight studies assessed the prevalence of insomnia within specific populations, such as veterans, nursing home residents, older adults with pain, and males and females. The prevalence of insomnia among veterans ranged from 23.3 to 56.8% [25, 26••], and among nursing home residents ranged from 44.4 to 67.9% [22, 27]. The prevalence of clinical insomnia in older adults with chronic pain was 24.6% [11]. The prevalence of insomnia was much higher in females, ranging from 41.5 to 74.8%, compared with males, ranging from 32.3 to 52.8% [3, 8, 28]. In addition, females were more likely to experience insomnia for more than 6 months [29•, 30].

Demographic and Sociocultural Correlates of Insomnia

Employment, living environment, and social support were all associated with insomnia outcomes. Ma and colleagues [23•] found that older adults with insomnia were more likely to have no education (42%), no fixed income (48%), less social contact with children (81%) and friends (48%), less spiritual (61%) and financial (56%) support, and lack of trustworthy family (166%???) and friends (67%). Other researchers reported similar results. Specifically, older adults who were not married [29•, 30], widowed [3], living alone [3, 23•, 30], living in less desirable neighborhoods [12••], unemployed [3, 6], of lower wealth status [30], working in a low-rank position [18], and having economic difficulties [3] were more likely to report insomnia.

Insomnia symptoms were more prevalent among Black and Hispanic older adults compared to White older adults [12••]. However, the relationship between race and insomnia symptoms was not significant in the regression analyses that included socioeconomic, health, and functional status as covariates, suggesting that the association could be explained by social-economic and health status factors [12••]. Nevertheless, Kaufmann and colleagues [31] noted that the severity of insomnia over time was disproportionately greater in Hispanics compared with non-Hispanic Whites, even after controlling for health conditions and body mass index.

Medical and Mental Health Correlates of Insomnia

The presence of one or more medical illnesses may increase the risk for insomnia. Insomnia may also worsen chronic illnesses. Older adults with insomnia were more likely to report at least two chronic illnesses compared to older adults without insomnia (83.5% vs. 56.5%) [5]. Some diseases noted were cardiovascular disease [5, 6, 29•], hypertension [5, 32•], coronary artery disease [3, 32•], atrial fibrillation [7], and hyperlipidemia [3, 6, 32•]. Furthermore, older adults with chronic pain who had clinical insomnia were more likely to experience pain more often and at a greater intensity compared those without insomnia [11].

Older adults tend to lose muscle mass and become weaker with age, thus, increasing their risk for frailty and falls. The presence of insomnia compounds this phenomenon. Insomnia was significantly associated with frailty [28] and fall risk in older adults [17, 24, 29•]. Chen and colleagues [33••] found that older adults with greater insomnia symptoms had a higher

Table 1 Characteristics of included studies

Authors	Design	Study name, Country	Sample size	Sleep measure	Demographics	Results	Quality score rating
Abell et al. (2015)	Prospective cohort, longitudinal	The White-hall II Cohort, UK	4491	Jenkins Sleep Problem Scale	Age range: 55–79 Female: 25.2%	The percentage of those participants who reported high levels of insomnia symptoms at each of the three time points was 8.2% (n = 368). Chronic insomnia symptoms were associated with poorer overall well-being (difference between insomnia at 3 assessments vs. none − 7.0 (SE = 0.4) $p < 0.001$), mental well-being (difference − 6.9 (SE = 0.4), $p < 0.001$) and physical well-being (difference − 2.8 (SE = 0.4), $p < 0.001$).	29
Adams et al. (2017)	Cross-sectional, online survey	Australia	175	International Classification of Sleep Disorders-3 criteria, ESS	Not reported	17.7% of older adults experienced insomnia. Sleep problems: 32% had difficulty falling asleep, 52% waking a lot during the night, 40% waking up too early and can't get back to sleep, 34.3% waking feeling unrefreshed. 60.6% report getting adequate sleep. Daytime symptoms: 15.4% daytime sleepiness, 24% fatigue/exhaustion, 13.1% irritable/moody, 13.1 average ESS score. 61.1% reported at least 1 sleep problem, and 39.4% reported at least 2 sleep problems.	30
Alcantara et al. (2016)	Prospective cohort	Multi-Ethnic Study of Athero-sclerosis Sleep Study, USA	1784	WHIIRS, ESS, PSG, actigraphy, sleep diary	Age range: 54–93 Female: 54% White: 36.8% Black: 28%, Hispanic: 23.7%, Chinese: 11.5%	29.3% had insomnia (WHIIRS ≥ 10), 14.1% had excessive daytime sleepiness. Depression was associated with insomnia (PR = 1.83, 95% CI = 1.39, 2.40) and excessive daytime sleepiness (PR = 1.61, 95% CI = 1.19, 2.18). Insomnia was more strongly associated with depression among men than women.	32
Alessi et al. (2016)	Randomized controlled trial	USA	60 (≥ 60)	ISI, sleep diary, PSQI, actigraphy	Mean age: 72.2 (7.7), Age range: 60–91, Female: 3.1%, Hispanic: 6.3%, Black: 4.4%, White: 78.6%, Other: 7.6%	More than 90% of subjects reported that their sleep problems had been present for longer than 12 months. Compared with participants in the control group, participants who received CBTi (5 sessions) had greater improvements at the post-treatment, 6-month assessments, and 12-month assessments: sleep diary-sleep onset latency (− 23.4, − 15.8, and − 17.3 min, respectively), sleep efficiency (10.5%, 6.7%, and 5.4%, respectively), PSQI (− 3.4, − 2.4, and − 2.1 in total score, respectively), and ISI (− 4.5, − 3.9, and − 2.8 in total score, respectively) (all $p < 0.05$).	32
Altintas et al. (2018)	Cross-sectional	Turkey	291 (≥ 60)	ISI	Mean age: 76.18 (8.06), Age range: 60–96, Female: 33.7%	14.1% had moderate insomnia, 2.7% had severe insomnia. 16.8% experienced insomnia at a clinical level.	29
Baron et al. (2017)	Pilot intervention	USA	17 (≥ 55)	Insomnia diagnosed by sleep clinician, PSQI, actigraphy	Mean age: 61.6 (4.3), Female: 94.1%	Participants had an average wake after sleep onset of 57 min per night at baseline. Greater variability in objective sleep measures were associated with poorer subjective sleep quality on the global scale of PSQI for wake after sleep onset ($p < 0.01$), sleep efficiency ($p < 0.05$), and fragmentation index ($p < 0.01$). Greater variability in sleep onset time (actigraphy) was associated with higher body mass index ($p < 0.05$).	30

Table 1 (continued)

Authors	Design	Study name, Country	Sample size	Sleep measure	Demographics	Results	Quality score rating
						Sleep efficiency and wake after sleep onset variability decreased with 16 weeks of sleep intervention (sleep hygiene and aerobic exercise activity or nonphysical activity-social, educational activity) ($p < 0.05$).	
Brenes et al. (2016)	Randomized controlled trial	USA	141 (≥ 60)	ISI	Mean age: 66.8 (6.2), Age range: 60–87, Black: 5.7%, White: 90.8%, Other: 3.5%	Symptoms of insomnia (ISI) declined among participants who received both CBT-T (telephone) and telephone-delivered nondirective supportive therapy on sleep in patients with generalized anxiety at the 4-month visit, but participants in the CBT-T intervention experienced significantly greater improvement ($F = 10.21$; df = 1136; $p = 0.002$). Improvements in insomnia were maintained at the 15-month assessment.	28
Cao et al. (2016)	Prospective cohort	China	1168 (≥ 60)	Self-report insomnia symptoms	Mean age: 70.70 (7.07), Age range: 60–94, Female: 52.4%	31.8% had self-reported insomnia. Self-reported insomnia ($p < 0.05$) was significantly associated with depression.	30
Caroll et al. (2016)	Cross-sectional	USA	126	DSM-4 and ICSD-2 criteria for primary insomnia	Mean age: 70.7 (6.6), Age range: 60–88, Female: 54.7%	Age (60–69 years vs. 70–88 years) and insomnia diagnosis interacted to predict shorter telomere length. In the oldest age group (70–88), telomere length was significantly shorter in those with insomnia compared to controls with no insomnia. In the adults aged 60–69, telomere length was not different between insomnia cases and controls.	31
Castello-Domenech et al. (2016)	Descriptive cross-sectional	Spain	99	Athens insomnia scale, Oviedo sleep question-naire	Mean age: 82.5 (0.8), Age range: 65–99, Female: 80.8%	67.9% of the participants had insomnia based on the Oviedo questionnaire. The average "insomnia" score based on the Oviedo questionnaire was 19.1 ± 1 (range 9–39). The mean Athens score was 4.4 ± 0.4 (range 0–16). There was no significant correlation between cognitive function (measured by the MMSE) and the Athens scale or the Oviedo questionnaire in persons living in nursing homes without a diagnosis of dementia. There was a significant correlation between cortisol and Oviedo questionnaire subscale for evaluating insomnia-related adverse events.	29
Chan et al. (2017)	Randomized controlled trial	USA	62	Sleep diaries, actigraphy	Mean age: 69.45 (7.71), Female: 68%, White: 82.26%, Hispanic: 6.45%, Black: 3.23%, Asian: 3.23%, Multiracial: 4.84%	Variabilities in sleep-diary assessed sleep onset latency significantly decreased in brief behavioral therapy for insomnia compared with self-monitoring attention control (Pseudo $R^2 = 0.12$; $p = 0.018$). These effects were mediated by reductions in bedtime and wake time variability and time in bed. Their actigraphy-assessed sleep onset latency and sleep efficiency also improved (Pseudo $R^2 = 0.15$ to 0.66; $p < 0.001$ to 0.044).	31
Chen et al. (2017)	Longitudinal	Health and Retirement Study (2006–2014), USA	6882	4 questions on insomnia symptoms	Mean age: 74.5 (6.6), Female: 57.4%, White: 85.7%,	6.6% used non-physician recommended sleep medications and 11.8% used physician-recommended sleep medications. Mean number of insomnia symptoms (0–4): 1.90. Older adults who fell reported a greater number of insomnia	27

Table 1 (continued)

Authors	Design	Study name, Country	Sample size	Sleep measure	Demographics	Results	Quality score rating
					Non-White: 14.3%	symptoms compared with those who did not fall. A greater burden of insomnia symptoms at baseline independently predicted falling after adjusting for known risk factors of falling. Older adults who reported one additional insomnia symptom at baseline were 5% more likely to fall at follow-up. Insomnia symptoms and using physician-recommended sleep medications at baseline were significant predictors of any fall at follow-up. Compared with participants who did not take any sleep medications, the probability of falling was consistently higher for all levels of insomnia symptoms among older adults who took physician-recommended sleep medications at baseline.	
Chiou et al. (2016)	Cross-sectional	The Shih-Pai Sleep Study, Taiwan	4047	PSQI, DSM-4 criteria of insomnia	Female: 44.2%	5.8% had insomnia, with 67.2% of those having insomnia for ≥ 6 months. The prevalence of insomnia disorder for 1 to 6 months and ≥ 6 months was 1.9% and 3.9%, respectively. Women ($p < 0.001$) and single individuals ($p = 0.005$) had a higher prevalence of insomnia disorder. Women had a higher prevalence of insomnia disorder for both duration quantifiers (1 to 6 months, 2.7% of women vs. 1.3% of men; and ≥ 6 months, 5.0% of women vs. 3.0% of men). Compared with married participants, single older adults had a higher prevalence of insomnia disorder for both duration quantifiers (1 to 6 months, 3.0% of single individuals vs. 1.6% of married individuals; ≥ 6 months, 4.6% of single individuals vs. 3.6% of married individuals). Insomnia disorder was significantly associated with heart disease ($p < 0.001$), stroke ($p = 0.002$), pulmonary diseases ($p = 0.001$), depression ($p < 0.001$), excessive daytime sleepiness ($p = 0.01$), pain ($p < 0.001$), and falling ($p = 0.001$). Insomnia disorder between 1 and 6 months was associated with being a woman (OR; 2.16, 95% CI; 1.33–3.51), having pulmonary diseases (OR; 2.57, 95% CI; 1.46–4.52), having depression (OR; 2.81, 95% CI; 1.59–4.96), and moderate pain (OR; 2.56, 95% CI; 1.23–5.32). Insomnia disorder for more than 6 months was associated with being a woman (OR; 1.50, 95% CI; 1.07–2.10) and having heart disease (OR; 1.73, 95% CI; 1.21–2.49), depression (OR; 4.68, 95% CI; 3.24–6.75), or moderate and severe pain (OR; 2.23, 95% CI; 1.26–3.93 and OR; 2.34, 95% CI; 1.14–4.40) respectively.	29
Culver et al. (2016)	Cross-sectional	USA	Total: 1538 257 (60–69 years) 145 (≥ 70 years)	Insomnia Treatment Acceptability Scale, PSQI, ICSD-3 criteria, ISI, STOP Questionnaire	Mean age: 51.8 (14.6), Female: 100%, White: 66.3%, Black: 26.5%,	60–69 group: 28.6% reported insomnia medication treatment as very acceptable and 51% reported non-medication treatment very acceptable. ≥ 70-year group: 16.9% reported insomnia medication treatment as very acceptable and 37.1% reported non-medication treatment very acceptable.	31

Table 1 (continued)

Authors	Design	Study name, Country	Sample size	Sleep measure	Demographics	Results	Quality score rating
					Hispanic: 6.5%, American Indian/Alaska Native: 2.9%, Asian/Asian American: 1.7%		
Devkota et al. (2017)	Cross-sectional	Nepal	253 (≥ 60)	Self-reported physical and mental well-being	Female: 68%, Janajati: 82.5%, Khas/Arya: 15.5%, Dalit: 2.4%	37.8% of the male pensioners reported insomnia and 53.8% of the female pensioners reported insomnia. Insomnia was associated with increased frailty in univariate models.	30
DiNapoli et al., (2016)	Cross-sectional	USA	879 (≥ 65)	International Classification of Diseases (9th edition)	Mean age: 76.5 (6.39), Female: 1.9%, White: 85.4%, Black: 11.9%, Other:1.5%, Unknown:1.2%	23.2% of the sample had insomnia. 41.7% of them used any sedative hypnotics, 14.7% used z-drugs (selective benzodiazepine receptor agonists, i.e., eszopiclone, zaleplon, zolpidem), 14.7% used Trazadone, 11.8% used on-label benzos, 3.9% used off-label benzos, 1% used hydroxyzine, and 2.5% used diphenhydramine. Older veterans with newly reported insomnia (41.7%) were most likely to receive a sedative hypnotic. Trazodone (6.7%) and on-label benzodiazepines (5.9%) were the most commonly prescribed sedative hypnotics to older veterans.	27
Dragioti et al., (2018)	Cross-sectional	Sweden	2790 (≥ 65)	ISI	Median age: 76, Age range: 70–82, Female: 52%	Participants with clinical insomnia were 24.6%. Lower overall well-being and quality of life were reported in severe clinical insomnia (i.e., ISI ≥ 22). Higher pain intensity, frequency, and total comorbidities were reported in severe clinical insomnia compared with the other subcategories of insomnia. The total annual healthcare costs were more than doubled in severe clinical insomnia compared with no clinically significant insomnia.	31
Endeshaw and Yoo (2016)	Cross-sectional	National Health Aging Trends Study, USA	7162 (≥ 65)	2 questions about insomnia symptoms	Female: 56%, White: 80%, Black: 8%, Hispanic:7%, Other: 5%	28% of study participants reported 1 or both insomnia symptoms. Difficulty in falling asleep, trouble staying asleep, and both insomnia symptoms were reported by 12%, 5%, and 11% of the participants, respectively. The proportion of study participants with insomnia symptoms was higher among women, Black and Hispanic participants, participants with lower education level, lower income, who reside in "not desirable" neighborhood, and who had poor health status and lower physical performance test scores. Participants engaging in organized social activity and/or walking exercise were significantly less likely to report insomnia symptoms. The risk of insomnia symptoms was lower in those who engaged in both activities versus those who engaged in one activity, suggesting the additive beneficial effect of two activities. Participants engaging in both activities were 40% less likely to report both insomnia	29

Table 1 (continued)

Authors	Design	Study name, Country	Sample size	Sleep measure	Demographics	Results	Quality score rating
						symptoms while participants who reported engaging in organized social activity and walking exercise were 30% and 22% less likely to report both insomnia symptoms, respectively.	
Endeshaw et al. (2016)	Prospective cohort	Healthy Aging Body Composition Study, USA	1478	Questions about insomnia, self-reported sleep duration	Mean age: 73.8 (2.9), Age range: 70–79, Female: 0%, White: 62.9%, Black: 37.1%	23.2% of the participants reported at least 1 insomnia symptom. The proportion of participants who reported insomnia symptoms was higher among those with increased frequency of nocturia episodes. Overall, 19%, 25%, and 33% of participants with 0–1, 2, and ≥ 3 nocturia episodes, respectively, reported one or more insomnia symptoms ($p < 0.001$).	28
Hartescu et al. (2016)	Cohort	Notting-ham Longitudinal Study of Activity and Aging, UK	926 (≥ 65)	Questions about insomnia symptoms	Female: 60.2%	21.6% of the baseline sample reported insomnia symptoms, with women reporting a significantly greater prevalence of insomnia symptoms than men. The higher level of walking was significantly and independently associated with a lower likelihood of reporting insomnia symptoms (OR = 0.67, 95% CI = 0.45–0.91, $p < 0.05$). Higher level of walking at baseline significantly predicted a lower likelihood of problems getting to sleep (OR = 0.64, 95% CI = 0.42–0.97, $p < 0.05$) and staying asleep (OR = 0.63, 95% CI = 0.41–0.95, $p < 0.05$), but not early morning awakening (OR = 0.63, ns) at the 4-year follow-up.	26
Helbig et al. (2017)	Cross-sectional	KORA Age Study, Germany	3833 (≥ 65)	Questions about insomnia symptoms	Mean age: 73 (5.8), Range: 65–93, Female: 51.3%	8.2% of the sample were classified as having insomnia. The prevalence of difficulty staying asleep was the highest in the whole sample (40.7%), followed by trouble falling asleep (16.6%). In comparison with respondents without insomnia, there was a higher proportion of women among those suffering from insomnia, and participants with insomnia were, on average, significantly older than those without insomnia. Many of the participants with insomnia reported chronic conditions including hypertension (71.4%), eye diseases (53.7%), and heart diseases (43.2%). The frequency of individual chronic conditions was higher in participants with insomnia versus those without insomnia. Participants with insomnia were more likely to suffer from 2 or more chronic conditions (83.5%), compared with those without insomnia (56.5%). The most frequent co-occurring pairs of chronic conditions among individuals with insomnia were hypertension/eye diseases (37.5%) and hypertension/heart diseases (33.3%). Although insomnia and all its unique symptoms were associated with multimorbidity among women, in the multivariable models, trouble falling asleep was not significant after adjusting for all covariables among men.	31

Table 1 (continued)

Authors	Design	Study name, Country	Sample size	Sleep measure	Demographics	Results	Quality score rating
						Among common pairs of conditions, associations were observed between insomnia with joint diseases/eye diseases in men and joint diseases/heart diseases in women.	
Hishikawa et al. (2017)	Cross-sectional	Japan	142	AIS	Mean age: 70.5 (9.7) Female: 50%	Subjective insomnia (AIS ≥ 4) was reported by 36.2% of participants and was more frequent in females than males. For both sexes, depressive symptoms were significantly higher in the AIS ≥ 4 subgroup than the AIS ≤ 3 subgroup. Apathy Scale scores were significantly higher in males in the AIS ≥ 4 subgroup. Of the AIS subscales, "sleepiness during the day" was significantly higher in females than males ($p < 0.01$), especially in those aged ≥ 75 years ($p < 0.01$). This group of older females also performed poorer on the Trail Making Test score ($p < 0.05$).	25
Huang et al. (2016)	Randomized controlled trial (crossover)	Taiwan	38 (≥ 50)	Actigraph with electroen--cepalogram, visual analog scale, PSQI	Mean age: 56.42 (6.35), Age range: 50–75, Female: 78.9%, Chinese: 5.3%, Taiwanese: 86.8%, Hakka: 7.9%	Listening to soothing music for 30 min before bedtime significantly shortened the wake time after sleep onset measured by electroencephalogram, compared with brisk walking on the treadmill with music for 30 min in the evening. Music was effective in reducing sleep onset latency ($p = 0.02$) and wake after sleep onset ($p < 0.001$), as measured using electroencephalogram.	36
Hung et al. (2018)	Case-control	Longitudinal Health Insurance Database of Taiwan's National Health Institute Research Database, Taiwan	12,025 (≥ 60)	Diagnosis based on International Classification of Disease, 9th edition,	Not reported	Patients with primary insomnia were more likely to have diabetes, dyslipidemia, hypertension, coronary artery disease, chronic liver disease, and chronic kidney disease. During the 3-year follow-up period, 1316 patients with primary insomnia (2.5% of the study cohort) compared with 3742 patients with non-primary insomnia (1.3% of the comparison cohort) developed dementia. For relative risk of dementia, the hazard ratio was 2.21 for 60–74 age group and 1.96 for 75+ years. Patients with primary insomnia have a higher longitudinal risk of developing dementia.	33
Ibanez-del Valle et al. (2018)	Cross-sectional	Spain	62 (≥ 60)	AIS, Oviedo questionnaire, actigraphy	Mean age: 82.8 (8.7)	20% of participants had insomnia based on the AIS. The average insomnia subscale (Oviedo subscale 2) score was 20.5 ± 6.9. Patients classified as patients with insomnia according to AIS score (score of ≥ 6) had higher blood plasma cortisol concentrations compared with the remaining group of individuals ($p < 0.01$).	29
Jackowska and Poole (2017)	Prospective cohort	English Longitudinal Study of Ageing, UK	Total:; 4545 (≥ 50), 3200 (≥ 60)	Insomnia questions from Jenkins Sleep Problems Scale	Not reported	Insomnia was more prevalent in women ($p < 0.001$), respondents who were neither married nor cohabiting ($p < 0.001$), were from lower wealth quintiles ($p < 0.001$), current smokers ($p = 0.04$), consumed alcohol less frequently ($p < 0.001$), engaged in moderate or vigorous physical activity less than once a week ($p < 0.001$), had higher body mass index (BMI) ($p < 0.001$), reported having a limiting long-standing illness ($p < 0.001$), had elevated depressive symptoms ($p < 0.001$), and were undergoing	28

Table 1 (continued)

Authors	Design	Study name, Country	Sample size	Sleep measure	Demographics	Results	Quality score rating
						treatment for depression ($p < 0.001$). Insomnia symptoms were associated with increased odds of elevated depressive symptoms 6 years later (OR = 1.36, 95% CI = 1.19–1.56, $p < 0.001$), independent of covariates. Difficulty falling asleep less than once a week, when compared with no difficulty during the past month, was predictive of higher odds of depressive symptoms (OR = 1.49, 95% CI = 1.06–2.11, $p = 0.023$). Waking in the morning feeling tired once or twice a week (OR = 1.43, 95% CI = 1.00–2.03, $p = 0.049$) and three or more times a week (OR = 1.71, 95% CI = 1.24–2.37, $p = 0.001$) also predicted depressive symptoms at follow-up.	
Kaufmann et al. (2016)	Cohort	Health and Retirement Study (2002–2010), USA	22,252 (≥ 50)	Questions about insomnia symptoms	Mean age: 63.96 (10.47), Female: 53.7%, White: 74%, Black: 14.4%, Hispanic: 9.8%, Other: 1.8%	Across all participants, the mean insomnia score increased modestly by 0.19 points (95% CI = 0.14–0.24; $t = 7.52$; $p < 0.001$) between 2002 and 2010 after controlling for baseline age, race/ethnicity, gender, and education. There were statistically significant increases for Whites, Blacks, and Hispanics. Hispanics experienced a greater increase in insomnia severity over time compared with Whites. After adjusting for multiple accumulated health conditions and BMI, the association between insomnia severity and time decreased substantially and changed direction ($B = -0.24$; 95% CI = − 0.29, − 0.19; $t = -9.22$; design df = 56; $p < 0.001$), suggesting that the observed worsening in insomnia severity was attributable to the accumulation of health conditions. Hispanics saw significantly greater increases in insomnia severity even after controlling for all variables. By race/ethnicity group, Hispanics had a statistically significant increase in insomnia score for "no health conditions" stratum, but no statistically significant change in insomnia for 1, 2 or 3+ health conditions. Among non-Hispanic Whites, there was no statistically significant change in the insomnia score for the no health conditions stratum, but a statistically significant decline in insomnia severity for the other three strata.	30
Kay et al., (2016)	Case-control	USA	135 (≥40)	Insomnia symptoms from Hamilton Rating Scale for Depression	Mean age: 66, Female: 47%, White: 86.9%	The suicide attempt group had significantly more severe insomnia than the suicidal ideation (p = 0.010) and non-suicidal depressed (p = 0.006) groups. Individuals with a suicide attempt had on average one more symptom of insomnia (29% greater insomnia severity) than the non-attempt groups. The suicide attempt group had more severe insomnia symptoms of a particular type (onset, maintenance, or early morning awakening) and on average had at least two different symptoms of insomnia.	31
Kim et al. (2017)	Cross-sectional		881 (≥ 60)		Mean age: 70.6 (7),		33

Table 1 (continued)

Authors	Design	Study name, Country	Sample size	Sleep measure	Demographics	Results	Quality score rating
		Osan Mental Health Survey, South Korea		Athens Insomnia Scale, ICSD-2, DSM-4 interview, PSQI, ESS	Female: 59%	The prevalence of insomnia was estimated to be 32.7% (95% CI = 29.6–35.8%). Insomnia was more prevalent in women than in men (37.9% vs. 25.2%; $p < 0.001$). Insomnia was less prevalent in the old-old group aged 80 years or older than in the young-old group aged 60–77 (22.4%, 95% CI = 14.7–30.0% vs. 34.2%, 95% CI = 30.9–37.6%, $p = 0.014$). The prevalence of insomnia subtypes were psychophysiological insomnia, 20.5%; insomnia due to mental disorder 7.2%; insomnia due to general medical conditions 2.9%; insomnia in other sleep disorders 2.2%, and insomnia due to substance use 0.2%. Female gender was associated with the risk of insomnia (OR = 2.40, 95% CI = 1.30–4.44, $p = 0.005$).	
Kuok et al. (2017)	Cross-sectional	China	451 (≥ 50)	Questions about insomnia symptoms	Mean age: 72 (10.5), Female: 78.7%	38.1% of the sample had insomnia. In the community, 13.7% had insomnia. In nursing homes, 44.4% had insomnia. Insomnia significantly predicted poor physical quality of life ($p = 0.02$).	29
Laredo-Aguilera et al. (2018)	Randomized controlled trial	Spain	38 (≥65)	Oviedo Sleep Questionnaire	Mean age: experimental group: 75.44 (5.31), control group: 76.35 (6.45); Female: 84.2%	Following the 10-week functional training program, the experimental group's insomnia scores decreased, but did not reach statistical significance (22.05 ± 12.51 to 16.45 ± 10.42; $p = 0.065$).	31
Larsson et al. (2017)	Cross-sectional	Sweden	2415 (≥ 65)	ISI	Mean age: 75.9% (7.4), Female: 60.1	The average ISI scores were highest among subgroup 1 (moderate pain and high psychological symptoms, 14.4 ± 5.2, $p < 0.001$). Subgroups 1 (moderate pain and high psychological symptoms, OR = 1.23, 95% CI: 1.17–1.28), 2 (high pain and moderate psychological symptoms, OR = 1.13, 95% CI: 1.08–1.17), and 3 (low pain and moderate psychological symptoms, OR = 1.10, 95% CI: 1.07–1.14) were also associated with increased levels of insomnia.	36
Li et al. (2018)	Secondary data analysis	USA	49 (≥ 55)	AIS, PSQI	Mean age: 66.3, Age range: 55–80, Female: 67% Non-White: 16%	Insomnia score decreased with time (10 weeks, change in the mean = − 1.8, SD = 3.4) regardless of the intervention (mindfulness intervention or sleep hygiene intervention). Change in insomnia scores was associated with change in depressive symptoms ($\beta = 0.38$, $p < 0.01$).	25
Lin et al., (2018)	Retrospective cohort study	National Health Insurance Research Database (2000–2013), Taiwan	192,358 (≥ 65)	International Classification of Diseases-9 criteria	Not reported	33.3% had insomnia. The risk of suicide attempts among insomnia patients aged 65 years and older was 1.595-fold ($p < 0.001$).	34
Ling et al. (2016)	Cross-sectional	Longitudinal Ageing Studies, Singapore	859	9 sleep questions: 3 regarding nocturnal sleep pattern, 3 insomnia, and 3	Mean age: 71.9, Age range: 65–94, Female: 59.4%	Insomnia complaints were present in 18.0% ($n = 155$) of the participants. Of these, 14.8% reported experiencing difficulty initiating sleep, 13.1% reported difficulty	33

Table 1 (continued)

Authors	Design	Study name, Country	Sample size	Sleep measure	Demographics	Results	Quality score rating
				from Hamilton Depression Rating Scale		maintaining sleep, and 10.7% reported early morning awakening in the past month. Participants experiencing at least one type of insomnia complaint were generally older than those who reported no insomnia ($p \leq 0.030$). They were more likely to report a history of medical conditions, such as gastro-intestinal disorders ($p \leq 0.043$). A higher percentage of those with difficulty initiating sleep reported a history of arthritis ($p = 0.016$) compared with those with no difficulty initiating sleep, while those with difficulty maintaining sleep consumed more medications (2.6 vs. 3.2; $p = 0.038$) and were more likely to report a history of kidney failure ($p = 0.046$) and thyroid problems ($p = 0.002$). Those with early morning awakening were more likely to report a history of stroke ($p = 0.048$) and atrial fibrillation ($p = 0.040$). Participants with any insomnia complaint reported greater depressive symptoms (I ≤ 0.012), but only those with experiencing difficulty initiating sleep had a significantly higher percentage of depressive symptoms (Geriatric Depression Scale ≥ 5, 1.7% vs. 6.0%; $p = 0.025$).	
Ma et al. (2018)	Cross-sectional	China	3045 (≥ 60)	AIS	Mean age: 69.7 (7.4), Age range: 60–95, Female: 45%, Han: 97%	24% had insomnia and 9% had suspected insomnia. Having no fixed income ($p = 0.04$); living alone ($p = 0.007$), being socially less connected with children ($p < 0.001$), neighbors, or friends ($p < 0.001$), disagreeing about having spiritual or financial support during difficulty ($p < 0.001$), and lack of trustworthy relationship with children ($p = 0.02$), neighbors, or friends ($p = 0.004$, $p = 0.05$, respectively), were all significantly associated with higher likelihood of suffering from severe insomnia.	34
Manjavong et al. (2016)	Cross-sectional	Healthy Ageing Khon Kaen Univeresity Campus Project, Thailand	491 (≥ 50), 95 (≥ 65)	International Classification of Diseases-10 criteria	Female: 65.8%	60% of the participants had insomnia. The significant consequences related to insomnia were feeling unrefreshed ($p < 0.001$), daytime sleepiness ($p = 0.002$), need for a sedative drug ($p < 0.001$), depression ($p = 0.002$), and impaired attention ($p < 0.001$).	32
Moreno-Vecino et al. (2017)	Cross-sectional	Research Network in Exercise and Health for Special Populations, Spain	463 (≥ 65)	Jenkins Sleep Scale	Age range: 66–91, Female: 100%	Participants with insomnia had significantly greater values of body mass index (30.0 ± 4.4 kg/m^2 vs. 28.9 ± 4.2 kg/m^2, $p < 0.05$, with and without sleep disorders, respectively), and waist circumference (94.1 ± 11.5 cm vs. 91.3 ± 10.3 cm, $p < 0.01$, with and without sleep disorders, respectively) than those with proper sleep. Women without sleep disturbance had greater lower body strength (13.9 ± 4.0 vs. 14.7 ± 3.5 repetitions, $p < 0.05$), upper body strength (18.5 ± 4.1 vs. 17.2 ± 4.0 repetitions, $p < 0.001$), agility (6.4 ± 2.4 vs. 6.1 ± 2.0 s, $p < 0.01$), and walking speed (19.0 ± 5.5 vs. 17.2 ± 4.0 s, $p < 0.05$), compared with women with sleep	35

Table 1 (continued)

Authors	Design	Study name, Country	Sample size	Sleep measure	Demographics	Results	Quality score rating
						disturbances (with and without sleep disturbance, respectively). Women without sleep disturbance reported better health related quality of life as compared with those with it (73.3 ± 1.7 vs. 65.7 ± 1.9, $p < 0.05$, respectively). Women with better physical condition had lower risk of suffering from sleep disturbance by 92% (odds ratio, OR = 0.52, 95% CI 0.251–1.083) compared with women with lower physical condition ($p = 0.08$).	
Morita et al. (2017)	Longitudinal (repeated measures non-randomized crossover)	Japan	43 (≥ 55)	AIS, PSG	Mean age: 58.9 (3.6), 57.7 (2.9), Age range: 55–65, Female: 58.1%	69.7% of the participants had primary insomnia (34.8% difficulty initiating sleep, 34.8% early morning awakening). No significant effect of the morning and evening exercise on the insomnia symptoms.	32
Nowicki et al. (2016)	Cross-sectional	NATPOL study, Poland	590 (≥ 60)	3 questions about sleep	Age range: 60–79, Female: 27.6%	74.8% of the female participants aged 60–79 had subjective insomnia. 55.6% reported difficulty falling asleep, 52.5% reported difficulty with sleep maintenance, and 20.1% reported early morning awakening. Among male participants aged 60–79, 52.9% had subjective insomnia. 50.2% reported difficulty falling asleep, 37.2% reported difficulty with sleep maintenance, and 33.2% reported early morning awakening. Age and gender were the most important factors for prevalence of self-reported insomnia. There was no correlation between self-reported insomnia and body mass index, level of education, or place of residence.	25
Sakamoto et al. (2017)	Cross-sectional	India	112 (≥ 60)	ISI	Mean age: Males: 71.3 (7), Females: 67.9 (6.5); Female: 58%	The mean score of ISI was 2.8 (3.6) among males and 4.1 (4.4) among females. The prevalence of ISI (8 or more) was 15.2%. The prevalence of ISI (8 or more) among older adults living at the altitudes of 2800–3000 m, 3000–3500 m, and 3500–4200 m was 0%, 10.5%, and 28.9%, respectively ($p = 0.002$). Altitude of residence was significantly related to ISI ($R = 0.350$, $p < 0.001$). Living at higher altitude (odds ratio [OR] 1.003, 95% confidence interval [95% CI] 1.000–1.005, $p = 0.020$) was an independent risk factor for insomnia.	32
Tang et al. (2017)	Cross-sectional	USA	367 (≥ 60)	ISI, PSQI	Mean age: 72.9 (8.2), Female: 78.5%, White: 90.1%, Non-White: 9.9%	All participants had clinically significant insomnia (ISI 12.8 ± 4.8). Sex, education, and fatigue predicted ISI nighttime sleep complaints ($R^2 = 0.187$; $F = 11.458$ ($p < 0.001$)). Fatigue, depression, and pain predicted daytime sleep-related consequences for ISI ($R^2 = 0.418$; $F = 33.742$ ($p < 0.000$)). When measures of sleep and pain beliefs/attitudes were added, depression was no longer a significant predictor of ISI daytime consequences. Education, fatigue, sleep beliefs, and pain beliefs predicted ISI nighttime sleep complaints ($R^2 = 0.222$; $F = 21.334$ ($p <$	28

Table 1 (continued)

Authors	Design	Study name, Country	Sample size	Sleep measure	Demographics	Results	Quality score rating
						0.001), R^2 change 0.030; F change 7.023 ($p < 0.001$)). Fatigue and sleep beliefs predicted ISI daytime sleep-related consequences ($R^2 = 0.458$; $F = 61.113$ ($p < 0.001$), R^2 change 0.045; F change 15.114 ($p < 0.001$)).	
Uchmanowicz et al. (2019)	Cross-sectional	Poland	100	ESS, AIS	Mean age: 65.5 (15.6), Female: 41%	59% of the participants had insomnia based on the AIS scale. Insomnia was more common in participants who were elderly ($p = 0.001$); non-working ($p = 0.005$); overweight ($p = 0.042$); clinically diagnosed with hypertension ($p = 0.014$), comorbid hypercholesterolemia ($p = 0.007$), or ischemic heart disease ($p = 0.036$); characterized by a lack of knowledge about the symptoms of hypertension ($p = 0.028$) or complications of hypertension ($p = 0.003$); and patients who were more frequently hospitalized due to complications of hypertension ($p < 0.001$). There was a negative correlation between AIS score and all domains of quality of life. Insomnia had most effect on physical ($r = -0.582$, $p = 0.001$) and psychological domain of quality of life ($r = -0.520$, $p < 0.001$).	35
Wang et al. (2016)	Cross-sectional	China	3716 (≥ 60)	Questions about insomnia	Mean age: 69.4 (6.8), Female: 59.3%	37.8% of the participants had insomnia. The overall proportion of insomnia in women was significantly higher than in men (41.5% vs. 32.3%, $p < 0.05$). The most common type of sleep disturbance was difficulty maintaining sleep (25.2%; 21.8% in men vs. 27.4% in women; $p < 0.05$), followed by difficulty initiating sleep (16.6%; 10.3% in men vs. 20.9% in women; $p < 0.05$) and early morning awakening (12.2%; 11.2% in men vs. 12.9% in women; $p > 0.05$). The prevalence of sleep disturbances significantly increased with age ($p < 0.05$). Among the subjects with insomnia, only 21.9% were taking sleep medications. Never smoking (odds ratio [OR] = 1.48, 95% confidence interval [CI] = 1.06–2.06), experiencing the loss of a parent (OR = 1.60, 95% CI = 1.25–2.05), and depression symptoms (OR = 2.72, 95% CI = 1.61–4.59) were independent risk factors for risk factors for insomnia in men. Occasional drinking (OR = 0.59, 95% CI = 0.40–0.86) was an independent protective factor against insomnia in men. Older age (OR = 1.48, 95% CI = 1.10–1.99), depression symptoms (OR = 3.11, 95% CI = 2.22–4.35), a history of cerebral hemorrhage (OR = 4.39, 95% CI = 1.68–11.45), a history of hyperlipidemia (OR = 1.35, 95% CI = 1.08–1.68), living without a spouse (OR = 1.68, 95% CI = 1.08–2.61), and having mild cognitive impairment (OR = 1.38, 95% CI = 1.08–1.76) were independent risk factors for insomnia in women.	34

Table 1 (continued)

Authors	Design	Study name, Country	Sample size	Sleep measure	Demographics	Results	Quality score rating
Wilckens et al. (2016)	Randomized controlled trial	AgeWise program project, USA	77 (≥ 60)	PSQI, PSG	Mean age: 71.67, Age range: 60–87, Female: 68.4%, White: 93.5%	Lower wake after sleep onset was associated with higher delayed recall performance. Participants in the brief behavioral therapy for insomnia group exhibited significantly greater improvements in WASO relative to those in the control condition.	30
Wilckens et al. (2017)	Uncontrolled experimental trial	AgeWise program project, USA	48 (≥ 60)	PSG, insomnia based on DSM-IV/ICSD-2 criteria and ISI score ≥ 10	Mean age: 69.26 (7.87), Age range: 60–93, Female: 60.4%, White: 87.5%	Mean ISI for insomnia group was 14.67 (4.56) pre-intervention and 5.58 (4.48) post-intervention. 75% had wake after sleep onset latency complaints and 70.8% had sleep onset latency complaints. Wake after sleep onset showed a significant main effect of time point, indicating improvement following CBTi (t (37) = 6.30, $p < 0.001$). Reductions in wake after sleep onset were significantly associated with improvements in repetition trial accuracy, R^2 change = 0.13, $\beta = 0.372$, $t = 2.51$, $p = 0.017$.	34
Yeung et al., (2018)	Secondary analysis of Randomized Controlled Trial	USA	106 (≥60)	Actigraphy, sleep diaries, PSQI, ISI	Mean age: 72.1 (79) Female: 3.8%. White: 78.3%, Hispanic: 6.6%, Black: 5.7%	The ISI for the group was 11.7 (5.3). There was no difference among the CBTi with low physical activity group ($N = 46$) and CBTi with high physical activity group ($N = 60$) on the ISI score ($p = 0.1$) at baseline, post-treatment, 6-month, and 1-year follow-up. All participants (older veterans) experienced an improvement in ISI score.	34
Zhang et al. (2017)	Cross-sectional	Boston Puerto Rican Health Study and Boston Puerto Rican Osteoporosis Study, USA	439 (≥ 60)	Insomnia questions	Age range: 60–79	Among participants ≥ 60 years, 11% had insomnia disorder. Participants aged 60 years and older reported fewer insomnia symptoms (chi-square = 13.1, $p < 0.01$) than those younger than 60 years. Insomnia was associated with 49% greater risk of falls in adults 60 years or older ($p < 0.05$), and in women, but not in those younger than 60 years, or in men. Insomnia was not associated with recurrent falls or fractures.	36

AIS Athens Insomnia Scale, *CBT* cognitive behavioral therapy, *CBTi* cognitive behavioral therapy for insomnia, *DSM Diagnostic and Statistical Manual for Mental Disorders*, *ESS* Epworth Sleepiness Scale, *ICSD* International Classification of Sleep Disorders, *ISI* Insomnia Severity Index, *MMSE* Mini Mental State Examination, *PSG* polysomnography, *PSQI* Pittsburgh Sleep Quality Index, *UK* United Kingdom *USA* United States of America, *WHIIRS* Women's Health Initiative Insomnia Rating Scale

risk of falling, and older adults who reported one additional insomnia symptom at baseline were 5% more likely to fall at follow-up.

Chronic insomnia symptoms in older adults were associated with poor mental health [18]. Insomnia symptoms, specifically difficulty initiating sleep compared with difficulty maintaining sleep or early morning awakenings, were significantly associated with depression [3, 7, 16, 20, 29•]. Surprisingly, the association of insomnia with depression was greater in men than in women [19]. Older adults with insomnia had a 1.59-fold risk for suicide attempts [34] and severe insomnia moderated the relationship between older adults with depression and suicidality [35].

Insomnia increased the risk for short-term or long-term cognitive impairment. Older adults with insomnia were significantly more likely to have impaired attention compared with those without insomnia [4]. Furthermore, older adults with insomnia performed worse on a cognitive task (executive function) compared with those without insomnia [36]. In a case-control study with a follow-up after 3 years, insomnia was independently associated with a 2.17-fold higher risk of subsequent development of dementia, and younger patients with primary insomnia had a higher risk of developing dementia [32•]. However, Castello-Domenech and colleagues [27] found that global cognitive performance, measured by the Mini-Mental State Exam, did not correlate with insomnia symptoms in older adults in nursing homes.

Non-pharmacologic Management of Insomnia

Behavioral Therapies

Dysfunctional attitudes and beliefs surrounding sleep were strong predictors of insomnia [37••]. Cognitive behavioral therapy insomnia (CBTi) is a multisession, multicomponent intervention which includes the following: stimulus control techniques (helping the patient associate the bed with sleep instead of being awake), sleep compression or restriction strategies (reducing the amount of time spent in bed to consolidate sleep), cognitive restructuring (techniques that challenge thoughts that interfere with sleep), and sleep hygiene [9, 38, 39]. Sixty, older veterans had significant improvements in sleep onset latency, sleep efficiency, total wake time, and insomnia symptoms immediately, at 6 months, and at 12 months post-treatment, after receiving five sessions of CBTi when compared with a sleep education program [40••]. While the sleep variables increased between the post-intervention and the 12-month assessment, the participants' symptoms remained significantly improved at 12 months when compared with baseline measures [40••]. Results from a secondary data analysis showed that 160 veteran participants who received the same CBTi protocol experienced a significant decrease in insomnia (5 points over a 12-month period) regardless of levels of physical activity [41]. In 141 older adults living in a rural setting and having generalized anxiety disorder, telephone-delivered CBT significantly improved insomnia symptoms over a 15-month period compared to a control intervention (7.39, CBT vs. 2.59, control) [42••].

Brief Behavioral Therapy for Insomnia (BBTi) is the shortened version of CBTi. Four weeks of BBTi resulted in improved sleep onset latency for 27 older adults with chronic insomnia compared to a self-monitoring attention control group (n = 23) with chronic insomnia [43••]. Specifically, subjective sleep onset latency decreased by about 48% in the BBTi recipients compared to a 22% decrease in the self-monitoring attention control group [43••]. Wilckens and colleagues [44] also found that 4 weeks of BBTi (2 in-person sessions and 2 phone calls) resulted in a significant decrease of 23 min in wake after sleep onset compared with the control group, which only had an increase of 3 min of wake after sleep onset.

Exercise

Laredo-Aguilera and colleagues [45] found that older adult participants (n = 38) had a 6-point, non-significant decrease in their insomnia scores after participating in a 10-week functional training program which included aerobic exercise, strength training, and balance training. Morning exercise compared with evening exercise did not result in any change in insomnia symptoms for 43 participants, but those who were in the morning exercise group had less shifts in sleep stages during the night, as measured by polysomnography [46]. Older adults with regular physical activity, such as walking, were less likely to report insomnia symptoms [3, 12••, 21•, 30, 47]. Furthermore, older adults who participated in organized social activities, such as clubs and classes, were less likely to report insomnia symptoms [12••].

Mixed Interventions

A 16-week intervention study comparing the efficacy of sleep hygiene and aerobic exercise versus non-physical activities, such as social or educational activities, resulted in decreased wake after sleep onset by more than 30 min for both groups (n = 17) [48•]. Thirty-eight older adults participated in a crossover-controlled trial comparing the effects of listening to soothing music before bed and listening to music while walking on a treadmill, on insomnia symptoms [49•]. They reported that listening to music reduced sleep onset latency by 11 min and wake after sleep onset by 16 min, and exercising while listening to music reduced sleep onset latency by 12 min [49•]. Ninety-two percent of these participants preferred listening to music before bed.

Pharmacologic Treatments

Among older adults with insomnia in China, 21.9% used sleep medications, and 11.1% used sleep medications at least three times a week [3]. Among a sample of 879 veterans who were diagnosed with insomnia during the previous 12 months, 41.7% used sedative-hypnotics, 14.7% used selective benzodiazepine agonists (z-drugs), 14.7% used Trazadone, 11.8% used on-label benzodiazepines, 3.9% used off-label benzodiazepines, 2.5% used diphenhydramine, and 1% used hydroxyzine [26••]. However, sleep medications were less acceptable with increased age among 402 female veterans [25]. Specifically, 16.9% of the veterans over 70 years old reported insomnia medications as very acceptable compared with 28.6% of those between 60 and 69 years of age [25]. Sleep medications increase the risk for many side effects including falls. Older adults who used physician-recommended sleep medications experienced a consistently higher fall risk, regardless of the severity of their insomnia symptoms [33••].

Discussion

Although insomnia is not a normal part of aging, it is common among older adults and is often undertreated. In our review of 48 publications on insomnia in older adults published over the last 3 years, up to 75% of older adults experience symptoms of insomnia. Given that insomnia is associated with multiple chronic conditions and negative consequences such as falls, cognitive decline, and suicide, it is important to identify older adults who experience insomnia, for prevention or treatment, and to reduce the risk for the development, occurrence, or severity of these negative outcomes [5, 50, 51].

Measures of Insomnia

Healthcare providers in primary care offices should integrate an insomnia-screening questionnaire into their baseline and ongoing annual assessment forms. Some forms to consider include the following: Insomnia Severity Index [52], Epworth Sleepiness Scale [53], Athens Insomnia Scale [54], Pittsburgh Sleep Quality Index [55], Women's Health Initiative Insomnia Rating Scale [56], or Minimal Insomnia Symptoms Scale [57]. In addition, it is important to ask about risk factors for insomnia, such as medical comorbidities, substance use, recent falls, psychiatric conditions, and social factors, like employment status, living environment, and social relationships [38]. Living alone and not being able to trust someone, or not having contact with family and friends, can be stressful for older adults and further increase the risk for insomnia [23•]. Therefore, probing about the quality and type of living environment and social relationships can help to further identify potential factors associated with insomnia and guide the development of shared provider-patient treatment goals.

Objective sleep measures are not necessary to diagnose insomnia. However, actigraphy, which measures movement, uses algorithms to determine sleep and wake, and it can be used during treatment, in conjunction with a sleep diaries, to evaluate treatment effectiveness of interventions [38].

Management of Insomnia

After diagnosing insomnia, behavioral interventions like CBTi and BBTi are the first-line recommendations for treating insomnia. As recent studies have shown, both CBTi and BBTi have resulted in short- and long-term improvement in insomnia symptoms [40••, 44, 58••]. Since many primary care providers are often unfamiliar with implementing behavioral interventions for insomnia, these healthcare providers can collaborate with behavioral and sleep medicine providers, or refer their patients to healthcare providers specializing in sleep medicine. The Society of Behavioral Sleep Medicine also has resources for providers and a listing of members who conduct CBTi in each state [59]. Primary care providers can also complete specialized training courses for which they will receive continuing education credits. Insurance companies may not always cover CBTi sessions; therefore, some older adults, who usually have fixed incomes, may not be able to afford the sessions. However, healthcare providers can provide in office education about the basics of cognitive behavioral therapy for insomnia. Healthcare providers can also educate their patients about participating in organized social activities, listening to soothing music before bed, and exercising consistently, since all these activities appear to be protective from insomnia [49•]. Other therapies, such as acupuncture [60, 61] and bright-light therapies have also been shown to reduce symptoms of insomnia [38, 62••].

Many older adults prefer non-pharmacological management compared with pharmacological treatment for insomnia [25]; however, benzodiazepines and other sedative-hypnotics are still regularly prescribed to older adults, often at higher doses than recommended [25, 26••, 63]. The first-line treatment for insomnia is not pharmacological management since many sleep medications cause side effects like ataxia, falls, or residual sedation [33••, 64]. Additionally, recommendations for the use of prescription and over-the-counter sleep medications for treating insomnia are weak [65••]. Consequently, healthcare providers should intentionally identify and review medications of patients who are at a high risk for insomnia, such as veterans and persons with chronic pain [25, 26••]. Furthermore, if patients have been using sleep medications for more than 12 months, it is important to discuss the goal of working toward de-prescribing, while developing healthy sleep habits [66, 67]. If medications must be

prescribed, they should be used for a limited period, usually less than 6 months [68].

Sociodemographic Factors

African American and Hispanic older adults experience greater rates of insomnia compared to White older adults. However, African American older adults are under-diagnosed with insomnia. In one study, only 6.7% of African American participants were actually diagnosed with insomnia, although close to 20% of them had insomnia [69]. Non-Hispanic Black older adults had greater difficulty falling and staying asleep compared to non-Hispanic White older adults [70]. Potential explanations for these differences could stem from racism, discriminatory policies, and historical and structural oppression, which have contributed to African Americans in the USA having less access to economic, educational, and healthcare resources, thus increasing their risk for insomnia and poor sleep [71, 72]. Perceived racial discrimination is a significant predictor of sleep disturbance with individuals who experience perceived discrimination, as they are 60% more likely to experience sleep difficulties, even after adjusting for social, demographic, and mental health covariates [73].

Cognitive Function

Insomnia increases the risk for cognitive decline and dementia [74]. One potential mechanism is its association with amyloid β–related neurodegenerative processes. A recent study found that persons with insomnia have higher levels of cerebrospinal fluid amyloid-beta (Aβ) 42 levels when compared with those without insomnia [75]. The glymphatic system, which is a perivascular network throughout the brain, allows for the clearance of amyloid β and other interstitial solutes from the brain through the interaction of cerebrospinal fluid and intracellular fluid [76]. The glymphatic system exchange significantly increases during sleep, enabling the elimination of the various metabolites from the extracellular space that accumulate during wakefulness [77, 78]. Therefore, insomnia can potentially lead to an accumulation of amyloid β deposits, potentially initiating earlier cognitive decline. Healthcare providers can educate older adults about the mechanisms by which insomnia increases their risk for cognitive decline, the importance of developing good sleep habits, and seeking help when they have insomnia. Primary care providers can also conduct brief memory screens using instruments such as the Mini-Cog [79] of older adults with insomnia.

Conclusion

With the projected growth of the aging population to 98 million by 2060 [80], the number of persons at risk for, and experiencing insomnia, will increase. Insomnia is associated with poor quality of life and poor outcomes on the physical and psychological domains of quality of life [6, 11, 22]. Insomnia is also associated with increased healthcare costs for older adults [11]. Therefore, healthcare providers should be cognizant about assessing insomnia in all older adults, especially those who may be at greater risk, including veterans, women, and non-Whites, and specifically evaluate sociodemographic and life experience factors that can contribute to insomnia. These assessments should be performed at baseline visits and annual preventive visits, so older adults can receive early interventions and minimize the risk for insomnia to trigger or worsen comorbid conditions.

Funding information This research was supported by the National Institute on Aging (grant number R01AG054079).

Compliance with Ethical Standards

Conflict of Interest The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Human and Animal Rights and Informed Consent This article does not contain any studies with human or animal subjects performed by any of the authors.

References

Papers of particular interest, published recently, have been highlighted as:
- • Of importance
- •• Of major importance

1. American Psychiatric Association. Diagnostic and statistical manual of mental disorders. 5th ed. Arlington: American Psychiatric Publishing; 2013.
2. American Academy of Sleep Medicine. International classification of sleep disorders. Darien: American Academy of Sleep Medicine; 2014.
3. Wang YM, Chen HG, Song M, Xu SJ, Yu LL, Wang L, et al. Prevalence of insomnia and its risk factors in older individuals: a community-based study in four cities of Hebei Province. China Sleep Med. 2016;19:116–22.
4. Hishikawa N, Fukui Y, Sato K, Ohta Y, Yamashita T, Abe K. Cognitive and affective functions associated with insomnia: a population-based study. Neurol Res. 2017;39(4):331–6.
5. Helbig AK, Stockl D, Heier M, Thorand B, Schulz H, Peters A, et al. Relationship between sleep disturbances and multimorbidity among community-dwelling men and women aged 65-93 years: results from the KORA Age Study. Sleep Med. 2017;33:151–9.
6. Uchmanowicz I, Markiewicz K, Uchmanowicz B, Koltuniuk A, Rosinczuk J. The relationship between sleep disturbances and quality of life in elderly patients with hypertension. Clin Interv Aging. 2019;14:155–65.
7. Ling A, Lim ML, Gwee X, Ho RC, Collinson SL, Ng TP. Insomnia and daytime neuropsychological test performance in older adults. Sleep Med. 2016;17:7–12.

8. Nowicki Z, Grabowski K, Cubala WJ, Nowicka-Sauer K, Zdrojewski T, Rutkowski M, et al. Prevalence of self-reported insomnia in general population of Poland. Psychiatr Pol. 2016;50(1): 165–73.
9. Patel D, Steinberg J, Patel P. Insomnia in the elderly: a review. J Clin Sleep Med. 2018;14(6):1017–24.
10. Ohayon M, Wickwire EM, Hirshkowitz M, Albert SM, Avidan A, Daly FJ, et al. National Sleep Foundation's sleep quality recommendations: first report. Sleep Health. 2017;3(1):6–19.
11. Dragioti E, Bernfort L, Larsson B, Gerdle B, Levin LA. Association of insomnia severity with well-being, quality of life and health care costs: a cross-sectional study in older adults with chronic pain (PainS65+). Eur J Pain. 2018;22(2):414–25.
12.•• Endeshaw YW, Yoo W. Association between social and physical activities and insomnia symptoms among community-dwelling older adults. J Aging Health. 2016;28(6):1073–89 **A cross-sectional study among 7162 multiracial community-dwelling older adults examined the relationships between insomnia, walking exercise, and organized social activity. Participants reported trouble falling asleep, trouble maintaining, and both insomnia symptoms. However, participants who walked and/or were involved in social activity were less likely to report insomnia.**
13. Hawker S, Payne S, Kerr C, Hardey M, Powell J. Appraising the evidence: reviewing disparate data systematically. Qual Health Res. 2002;12(9):1284–99.
14. Adams RJ, Appleton SL, Taylor AW, Gill TK, Lang C, McEvoy RD, et al. Sleep health of Australian adults in 2016: results of the 2016 Sleep Health Foundation national survey. Sleep Health. 2017;3(1):35–42.
15. Kim KW, Kang SH, Yoon IY, Lee SD, Ju G, Han JW, et al. Prevalence and clinical characteristics of insomnia and its subtypes in the Korean elderly. Arch Gerontol Geriatr. 2017;68:68–75.
16. Manjavong M, Limpawattana P, Mairiang P, Anutrakulchai S. Prevalence of insomnia and related impact. Int J Psychiatry Med. 2016;51(6):544–53.
17. Gehrman P, Gooneratne NS, Brewster GS, Richards KC, Karlawish J. Impact of Alzheimer disease patients' sleep disturbances on their caregivers. Geriatr Nurs. 2018;39(1):60–5.
18. Abell JG, Shipley MJ, Ferrie JE, Kivimaki M, Kumari M. Association of chronic insomnia symptoms and recurrent extreme sleep duration over 10 years with well-being in older adults: a cohort study. BMJ Open. 2016;6(2):e009501.
19. Alcantara C, Biggs ML, Davidson KW, Delaney JA, Jackson CL, Zee PC, et al. Sleep disturbances and depression in the multi-ethnic study of atherosclerosis. Sleep. 2016;39(4):915–25.
20. Cao W, Guo C, Ping W, Tan Z, Guo Y, Zheng J. A community-based study of quality of life and depression among older adults. Int J Environ Res Public Health. 2016;13(7).
21.• Hartescu I, Morgan K, Stevinson CD. Sleep quality and recommended levels of physical activity in older people. J Aging Phys Act. 2016;24(2):201–6 **Walking at or above the international standard of >/=150 min per week correlated with lower reporting of insomnia symptoms among older adults in UK using exploratory longitudinal analyses. Higher walking levels at baseline predicted lower reporting of sleep onset and sleep maintenance problems.**
22. Kuok K, Li L, Xiang YT, Nogueira B, Ungvari GS, Ng CH, et al. Quality of life and clinical correlates in older adults living in the community and in nursing homes in Macao. Psychogeriatrics. 2017;17(3):194–9.
23.• Ma Y, Hu Z, Qin X, Chen R, Zhou Y. Prevalence and socio-economic correlates of insomnia among older people in Anhui, China. Australas J Ageing. 2018;37(3):E91–e6 **A cross-sectional study to measure the prevalence of insomnia, as well as socio-economic correlations, was conducted among 3045 older people in China. Insomnia was prevalent in older Chinese adults and those lacking a fixed income and had minimal social capital and social contact, were more likely to develop insomnia. Therefore, socioeconomic interventions could help improve sleep quality.**
24. Zhang Y, Cifuentes M, Gao X, Amaral G, Tucker KL. Age- and gender-specific associations between insomnia and falls in Boston Puerto Rican adults. Qual Life Res. 2017;26(1):25–34.
25. Culver NC, Song Y, Kate McGowan S, Fung CH, Mitchell MN, Rodriguez JC, et al. Acceptability of medication and nonmedication treatment for insomnia among female veterans: effects of age, insomnia severity, and psychiatric symptoms. Clin Ther. 2016;38(11): 2373–85.
26.•• DiNapoli EA, Bramoweth AD, Cinna C, Kasckow J. Sedative hypnotic use among veterans with a newly reported mental health disorder. Int Psychogeriatr. 2016;28(8):1391–8 **Older veterans commonly used sedative hypnotics within 12 months of a new diagnosis, such as insomnia. The study collected retrospective and prospective data on 879 older veterans to compare sedative hypnotic use. Sedative hypnotics were commonly prescribed for older veterans, which are potentially inappropriate and should be avoided. Instead, brief behavioral therapy or cognitive behavioral therapy should be used for insomnia.**
27. Castello-Domenech AB, Del Valle VI, Fernandez-Garrido J, Martinez-Martinez M, Cauli O. Sleep alterations in non-demented older individuals: the role of cortisol. Endocr Metab Immune Disord Drug Targets. 2016;16(3):174–80.
28. Devkota S, Anderson B, Soiza RL, Myint PK. Prevalence and determinants of frailty and associated comorbidities among older Gurkha welfare pensioners in Nepal. Geriatr Gerontol Int. 2017;17(12):2493–9.
29.• Chiou JH, Chen HC, Chen KH, Chou P. Correlates of self-report chronic insomnia disorders with 1-6 month and 6-month durations in home-dwelling urban older adults - the Shih-Pai Sleep Study in Taiwan: a cross-sectional community study. BMC Geriatr. 2016;16: 119 **A cross-sectional survey was conducted to examine the correlates of chronic insomnia with different durations using 4047 home-dwelling older adults in Taiwan. Pulmonary diseases correlated with 1-6 month insomnia disorder; and heart disease and severe pain correlated with 6-month insomnia disorder. Correlates shared between 1-6 month and 6-month insomnia disorders were moderate pain, female gender, and depression.**
30. Jackowska M, Poole L. Sleep problems, short sleep and a combination of both increase the risk of depressive symptoms in older people: a 6-year follow-up investigation from the English Longitudinal Study of Ageing. Sleep Med. 2017;37:60–5.
31. Kaufmann CN, Mojtabai R, Hock RS, Thorpe RJ Jr, Canham SL, Chen LY, et al. Racial/ethnic differences in insomnia trajectories among U.S. older adults. Am J Geriatr Psychiatry. 2016;24(7): 575–84.
32.• Hung CM, Li YC, Chen HJ, Lu K, Liang CL, Liliang PC, et al. Risk of dementia in patients with primary insomnia: a nationwide population-based case-control study. BMC Psychiatry. 2018;18(1):38 **A case-control design of Taiwanese patients under 40 years of age having primary insomnia had a 2.14-fold risk increase of developing dementia when compared with those without primary insomnia. Sociodemographic characteristics and comorbidities were adjusted. Younger patients with primary insomnia are at an increased risk of developing dementia.**
33.•• Chen TY, Lee S, Buxton OM. A greater extent of insomnia symptoms and physician-recommended sleep medication use predict fall risk in community-dwelling older adults. Sleep. 2017;40(11) **A 2-year longitudinal study examined the interactive and independent effects of the degree of insomnia symptoms and sleep medications on fall risk among older-dwelling community adults. Sleep medication use resulted in variations of insomnia**

symptoms on fall risk. The use of physician-recommended sleep medications increased fall risks for older adults, with or without insomnia symptoms.

34. Lin HT, Lai CH, Perng HJ, Chung CH, Wang CC, Chen WL, et al. Insomnia as an independent predictor of suicide attempts: a nationwide population-based retrospective cohort study. BMC Psychiatry. 2018;18(1):117.
35. Kay DB, Dombrovski AY, Buysse DJ, Reynolds CF, Begley A, Szanto K. Insomnia is associated with suicide attempt in middle-aged and older adults with depression. Int Psychogeriatr. 2016;28(4):613–9.
36. Wilckens KA, Hall MH, Erickson KI, Germain A, Nimgaonkar VL, Monk TH, et al. Task switching in older adults with and without insomnia. Sleep Med. 2017;30:113–20.
37.•• Tang HJ, SM MC, Pike KC, Von Korff M, Vitiello MV. Differential predictors of nighttime and daytime sleep complaints in older adults with comorbid insomnia and osteoarthritis pain. J Psychosom Res. 2017;100:22–8 **A secondary data analysis involving 367 older adults with insomnia and osteoarthritis was performed to compare predictors of nighttime sleep complaints and daytime sleep-related consequences. Compared with depression and pain, individual attitudes and beliefs about sleep and pain highly predicted sleep difficulties. Furthermore, fatigue was the greatest predictor for daytime sleep-related consequences and nighttime sleep complaints.**
38. Brewster GS, Riegel B, Gehrman PR. Insomnia in the older adult. Sleep Med Clin. 2018;13(1):13–9.
39. Morin CM, Bootzin RR, Buysse DJ, Edinger JD, Espie CA, Lichstein KL. Psychological and behavioral treatment of insomnia:update of the recent evidence (1998-2004). Sleep. 2006;29(11):1398–414.
40.•• Alessi C, Martin JL, Fiorentino L, Fung CH, Dzierzewski JM, Rodriguez Tapia JC, et al. Cognitive behavioral therapy for insomnia in older veterans using nonclinician sleep coaches: randomized controlled trial. J Am Geriatr Soc. 2016;64(9):1830–8 **Veterans, 60 years old or more, participated in a RCT study using a newly developed, manual-based cognitive behavioral therapy for insomnia (CBT-I). One hundred fifty-nine veterans suffering from chronic insomnia participated in the study. The program consisted of five sessions (stimulus control, sleep restriction, sleep hygiene, cognitive therapy, and telephone supervision delivered by sleep coaches. Improved sleep was noted in older adults with chronic insomnia using manual-based CBT-I by sleep coaches.**
41. Yeung T, Martin JL, Fung CH, Fiorentino L, Dzierzewski JM, Rodriguez Tapia JC, et al. Sleep outcomes with cognitive behavioral therapy for insomnia are similar between older adults with low vs. high self-reported physical activity. Front Aging Neurosci. 2018;10:274.
42.•• Brenes GA, Danhauer SC, Lyles MF, Anderson A, Miller ME. Effects of telephone-delivered cognitive-behavioral therapy and nondirective supportive therapy on sleep, health-related quality of life, and disability. Am J Geriatr Psychiatry. 2016;24(10):846–54 **A secondary analysis of an RCT study was conducted among 141 rural-dwelling older adults diagnosed with generalized anxiety disorder (GAD). The effects of cognitive behavioral therapy (CBT) by telephone and telephone-delivered non-directive supportive therapy (NST) on sleep, health-related quality of life, and physical disability were compared among the participants. Telephone-CBT was superior to NST in reducing insomnia in both groups from baseline to 4 months, and these improvements were maintained at 15 months.**
43.•• Chan WS, Williams J, Dautovich ND, JPH MN, Stripling A, Dzierzewski JM, et al. Night-to-night sleep variability in older adults with chronic insomnia: mediators and moderators in a randomized controlled trial of brief behavioral therapy (BBT-I). J Clin Sleep Med. 2017;13(11):1243–54 **Sleep variability is commonly found in insomnia and it affects older adults. The RCT study examined sleep variability changes using brief behavioral therapy for insomnia (BBT-I). Sixty-two participants were assessed from baseline to post-treatment and at 3 months using sleep diaries and actigraphy. Variabilities in sleep onset latency (using diaries) and total sleep time (using actigraphy) were greatly decreased in participants of BBT-I; and those who had higher baseline sleep variability responded better to BBT-I. Effects were mediated by reductions in bedtime, wake time variability, and time in bed.**
44. Wilckens KA, Hall MH, Nebes RD, Monk TH, Buysse DJ. Changes in cognitive performance are associated with changes in sleep in older adults with insomnia. Behav Sleep Med. 2016;14(3):295–310.
45. Laredo-Aguilera JA, Carmona-Torres JM, Garcia-Pinillos F, Latorre-Roman PA. Effects of a 10-week functional training programme on pain, mood state, depression, and sleep in healthy older adults. Psychogeriatrics. 2018;18(4):292–8.
46. Morita Y, Sasai-Sakuma T, Inoue Y. Effects of acute morning and evening exercise on subjective and objective sleep quality in older individuals with insomnia. Sleep Med. 2017;34:200–8.
47. Moreno-Vecino B, Arija-Blazquez A, Pedrero-Chamizo R, Gomez-Cabello A, Alegre LM, Perez-Lopez FR, et al. Sleep disturbance, obesity, physical fitness and quality of life in older women: EXERNET study group. Climacteric. 2017;20(1):72–9.
48.• Baron KG, Reid KJ, Malkani RG, Kang J, Zee PC. Sleep variability among older adults with insomnia: associations with sleep quality and cardiometabolic disease risk. Behav Sleep Med. 2017;15(2):144–57 **Sleep variability is commonly found in insomnia and it affects older adults. A secondary analysis of sleep variability data was conducted. A cross-sectional analysis and change over time was evaluated for objective sleep variability in older adults with insomnia and short sleep duration, participating in a non-pharmacologic intervention study. Results supported previous findings suggesting that increased variability in objective sleep is associated with poor subjective sleep quality. Greater variability in sleep duration was correlated with higher HbA1c; and variability in sleep onset time was related to higher BMI. Also, objective sleep variability (sleep efficiency and WASO variability) can be improved with non-pharmacologic interventions.**
49.• Huang CY, Chang ET, Lai HL. Comparing the effects of music and exercise with music for older adults with insomnia. Appl Nurs Res. 2016;32:104–10 **A crossover controlled trial using 38 older adults with chronic insomnia was conducted to examine the effects of soothing music before bedtime, as well as, walking briskly on a treadmill in the evening with music, on sleep quality. Sleep quality was measured by questionnaires and an actigraph with EEG. While both interventions improved subjective sleep quality, listening to music before bedtime greatly reduced the wake time after sleep onset, as compared with brisk evening walks.**
50. Li L, Wu C, Gan Y, Qu X, Lu Z. Insomnia and the risk of depression: a meta-analysis of prospective cohort studies. BMC psychiatry. 2016;16(1):375.
51. Smagula SF, Stone KL, Fabio A, Cauley JA. Risk factors for sleep disturbances in older adults: evidence from prospective studies. Sleep Med Rev. 2016;25:21–30.
52. Bastien CH, Vallieres A, Morin CM. Validation of the Insomnia Severity Index as an outcome measure for insomnia research. Sleep Med. 2001;2(4):297–307.
53. Johns MW. A new method for measuring daytime sleepiness: the Epworth sleepiness scale. Sleep. 1991;14(6):540–5.
54. Soldatos CR, Dikeos DG, Paparrigopoulos TJ. The diagnostic validity of the Athens Insomnia Scale. J Psychosom Res. 2003;55(3):263–7.

55. Buysse DJ, Reynolds CF 3rd, Monk TH, Berman SR, Kupfer DJ. The Pittsburgh Sleep Quality Index: a new instrument for psychiatric practice and research. Psychiatry Res. 1989;28(2):193–213.
56. Levine DW, Kripke DF, Kaplan RM, Lewis MA, Naughton MJ, Bowen DJ, et al. Reliability and validity of the Women's Health Initiative Insomnia Rating Scale. Psychol Assess. 2003;15(2):137–48.
57. Westergren A, Broman JE, Hellstrom A, Fagerstrom C, Willman A, Hagell P. Measurement properties of the minimal insomnia symptom scale as an insomnia screening tool for adults and the elderly. Sleep Med. 2015;16(3):379–84.
58.•• van der Zweerde T, Bisdounis L, Kyle SD, Lancee J, van Straten A. Cognitive behavioral therapy for insomnia: a meta-analysis of long-term effects in controlled studies. Sleep Med Rev. 2019; **Cognitive behavioral therapy for insomnia is a treatment with moderate to large effects. This meta-analysis investigated long-term effects in 30 randomized controlled trials comparing CBT-I with non-active control groups. The primary analyses showed that CBT-I is effective at 3, 6, and 12 months compared with non-active controls. Although effects decline over time, CBT-I produces clinically significant effects that last up to a year after therapy.**
59. Thomas A, Grandner M, Nowakowski S, Nesom G, Corbitt C, Perlis ML. Where are the behavioral sleep medicine providers and where are they needed? A Geographic Assessment. Behav Sleep Med. 2016;14(6):687–98.
60. Cao HJ, Yu ML, Wang LQ, Fei YT, Xu H, Liu JP. Acupuncture for primary insomnia: an updated systematic review of randomized controlled trials. J Altern Complement Med. 2019;25(5):451–74.
61. Shergis JL, Ni X, Jackson ML, Zhang AL, Guo X, Li Y, et al. A systematic review of acupuncture for sleep quality in people with insomnia. Complement Ther Med. 2016;26:11–20.
62.•• van Maanen A, Meijer AM, van der Heijden KB, Oort FJ. The effects of light therapy on sleep problems: a systematic review and meta-analysis. Sleep Med Rev. 2016;29:52–62 **This is a meta-analysis which reviews the effect of light therapy on sleep problems in general and on specific types of sleep problems in particular. Fifty-three studies with a total of 1154 participants were included. Light therapy was found effective in the treatment of sleep problems in general ($g = 0.39$) and insomnia ($g = 0.47$). For insomnia, it may be useful to use a higher light intensity. Light therapy is effective for sleep problems in general.**
63. Martinez-Cengotitabengoa M, Diaz-Gutierrez MJ, Besga A, Bermudez-Ampudia C, Lopez P, Rondon MB, et al. Benzodiazepine prescriptions and falls in older men and women. Rev Psiquiatr Salud Ment. 2018;11(1):12–8.
64. Schroeck JL, Ford J, Conway EL, Kurtzhalts KE, Gee ME, Vollmer KA, et al. Review of safety and efficacy of sleep medicines in older adults. Clin Ther. 2016;38(11):2340–72.
65.•• Sateia MJ, Buysse DJ, Krystal AD, Neubauer DN, Heald JL. clinical practice guideline for the pharmacologic treatment of chronic insomnia in adults: an American Academy of Sleep Medicine Clinical Practice Guideline. J Clin Sleep Med. 2017;13(2):307–49 **The guideline establishes clinical practice recommendations for the pharmacologic treatment of chronic insomnia in adults, when the treatment is clinically indicated.**
66. Reeve E, Ong M, Wu A, Jansen J, Petrovic M, Gnjidic D. A systematic review of interventions to deprescribe benzodiazepines and other hypnotics among older people. Eur J Clin Pharmacol. 2017;73(8):927–35.
67. Sirdifield C, Chipchase SY, Owen S, Siriwardena AN. A systematic review and meta-synthesis of patients' experiences and perceptions of seeking and using benzodiazepines and z-drugs: towards safer prescribing. Patient. 2017;10(1):1–15.
68. Lam S, Macina LO. Therapy update for insomnia in the elderly. Consult Pharm. 2017;32(10):610–22.
69. Johnson DA, Wang R, Rueschman M, Wilson J, Redline SS. Undiagnosed sleep disorders in African Americans: the Jackson Heart Study 2017.
70. Grandner MA, Petrov ME, Rattanaumpawan P, Jackson N, Platt A, Patel NP. Sleep symptoms, race/ethnicity, and socioeconomic position. J Clin Sleep Med. 2013;9(9):897–905 a-d.
71. Turner AD, Lim AS, Leurgans SE, Bennett DA, Buchman AS, Barnes LL. Self-reported sleep in older African Americans and White Americans. Ethn Dis. 2016;26(4):521–8.
72. Patel NP, Grandner MA, Xie D, Branas CC, Gooneratne N. "Sleep disparity" in the population: poor sleep quality is strongly associated with poverty and ethnicity. BMC Public Health. 2010;10:475.
73. Grandner MA, Hale L, Jackson N, Patel NP, Gooneratne NS, Troxel WM. Perceived racial discrimination as an independent predictor of sleep disturbance and daytime fatigue. Behav Sleep Med. 2012;10(4):235–49.
74. de Almondes KM, Costa MV, Malloy-Diniz LF, Diniz BS. Insomnia and risk of dementia in older adults: systematic review and meta-analysis. J Psychiatr Res. 2016;77:109–15.
75. Chen DW, Wang J, Zhang LL, Wang YJ, Gao CY. Cerebrospinal fluid amyloid-beta levels are increased in patients with insomnia. J Alzheimers Dis. 2018;61(2):645–51.
76. Boespflug EL, Iliff JJ. The emerging relationship between interstitial fluid-cerebrospinal fluid exchange, amyloid-β, and sleep. Biol Psychiatry. 2018;83(4):328–36.
77. Rasmussen MK, Mestre H, Nedergaard M. The glymphatic pathway in neurological disorders. Lancet Neurol. 2018;17(11):1016–24.
78. Cordone S, Annarumma L, Rossini PM, De Gennaro L. Sleep and β-amyloid deposition in Alzheimer disease: insights on mechanisms and possible innovative treatments. Front Pharmacol. 2019;10:695.
79. Borson S, Scanlan J, Brush M, Vitaliano P, Dokmak A. The mini-cog: a cognitive 'vital signs' measure for dementia screening in multi-lingual elderly. Int J Geriatr Psychiatry. 2000;15(11):1021–7.
80. Colby S, Ortman JM, Bureau USC. Projections of the size and composition of the U.S. population: 2014 to 2060. 2015.