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The Effect of Sleep Medication Use and Poor Sleep Quality on Risk of Falls in Community-Dwelling Older Adults

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THE EFFECT OF SLEEP MEDICATION USE AND POOR SLEEP QUALITY ON RISK OF FALLS IN COMMUNITY-DWELLING OLDER ADULTS

A dissertation submitted in partial fulfillment of the requirements for the degree of Doctor of Philosophy at Virginia Commonwealth University

by

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List of Abbreviations

ADL	Activities of Daily Living
AGS	American Geriatrics Society
BGS	British Geriatrics Society
BMI	Body Mass Index
CBT	Cognitive Behavioral Therapy
CI	Confidence Intervals
CNS	Central Nervous System
CVS	Cardiovascular System
DBI	Drug Burden Index
DSM-5	Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition
ED	Emergency Department
ESS	Epworth Sleepiness Scale
FCI	Functional Comorbidity Index
FDA	Food and Drug Administration
FGA	Functional Gait Assessment
FICSIT	Frailty and Injuries Cooperative Studies of Intervention Techniques
FROP-Com	Falls Risk for Older People in the Community scale
GABA	γ-aminobutyric acid
HR	Hazard Ratio
HRS	Health and Retirement Study
IADL	Instrumental Activities of Daily Living
IRB	Institutional Review Board
IRR	Incidence Rate Ratio

MMSE	Mini Mental State Examination
MOR	Multivariate Odds Ratio
MT1	Melatonin Receptor Type 1
MT2	Melatonin Receptor Type 2
NOS	Newcastle-Ottawa Scale
NREM	Non-Rapid Eye Movement
NYAM	New York Academy of Medicine
OR	Odds Ratio
OSA	Obstructive Sleep Apnea
OTC	Over-the-Counter
PRISMA	Preferred Reporting Items for Systematic Reviews and Meta-Analyses
ProFaNE	Prevention of Falls Network Europe
PSG	Polysomnography
PSQI	Pittsburgh Sleep Quality Index
RAND	Research ANd Development
REM	Rapid Eye Movement
RLS	Restless Legs Syndrome
RR	Relative Risk
SAS	Statistical Analysis System
SD	Standard Deviation
SF-36	Short Form 36-item questionnaire
SSRIs	Selective Serotonin Reuptake Inhibitors
STROBE	Strengthening the Reporting of Observational Studies in Epidemiology
SWS	Slow Wave Sleep
TCA	Tricyclic Antidepressants

TUG	Timed Up & Go
U.S.	United States
VIF	Variance Inflation Factor
WHO	World Health Organization

Abstract

THE EFFECT OF SLEEP MEDICATION USE AND POOR SLEEP QUALITY ON RISK OF FALLS IN COMMUNITY-DWELLING OLDER ADULTS

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The work presented in this dissertation focuses on the association between sleep medication use, poor sleep, and falls in community-dwelling adults 65 years or older. Sleep complaints and the consumption of medications to aid sleep are common in older adults. Psychotropic medications, such as sedative hypnotics, are associated with risk of falls in older adults. However, very few studies have assessed the impact of poor sleep and sleep medication use on the risk of falls in community-dwelling older adults.

In the first project, a cross-sectional analysis of the Health and Retirement Study (HRS) 2010 data was conducted to determine the prevalence of sleep problems, sleep medication use and falls; and to evaluate the association between sleep problems, sleep medication use, and falls

in community-dwelling older adults. A multiple logistic model adjusted for covariates was used. In the sample of community-dwelling older adults, 35.8% had reported a fall and 40.8% had reported sleep problems in the past two years. Sleep medication use was reported by 20.9% of the older adults. Older adults who had sleep problems and took sleep medications had a significantly higher risk of falls compared with older adults who did not have sleep problems and did not take sleep medications. The other two groups, older adults who had sleep problems and did not take sleep medications, and those who did not have sleep problems and took sleep medications also had a significantly greater risk for falls.

The second project was a prospective cohort study of independently-living older adults from senior congregate housing. The effect of combined poor sleep quality and sleep medication use on risk of falls was assessed using logistic regression modeling. In this study of 113 community-dwelling older adults, 46.9% had at least one fall, and 62.8% had poor sleep quality. Sleep medication use was reported by 44.2% of the older adults. Older adults with poor sleep quality and sleep medication use had a significantly increased risk of falls compared with older adults with good sleep quality and no sleep medication use. Older adults with good sleep quality and sleep medication use, and those with poor sleep quality and no sleep medication use did not have a significantly greater risk for falls.

In conclusion, poor sleep added to sleep medication use significantly increased the risk of falls in community-dwelling older adults. The research undertaken in this dissertation was the first to evaluate the associations between poor sleep, use of sleep medications, and falls in community-dwelling older adults.

Chapter 1

Introduction

1.1 Sleep and Aging

Sleep patterns can be defined as two different physiologic states: REM (rapid eye movement) sleep and NREM (non-rapid eye movement) sleep. NREM is divided into stage 1, the lightest stage of sleep, to stage 4, deep sleep or slow-wave sleep. Sleep typically cycles between REM and NREM approximately every 90 minutes after an individual falls asleep until waking up and there is more REM sleep in the second half of the night.[1] In 2007, the American Academy of Sleep Medicine redefined the NREM stages as N1, N2, and N3, with N3 combining the traditional sleep stages 3 and 4 together and REM as stage R.[1,2]

There are quantitative and qualitative changes in sleep (e.g., increased sleep fragmentation, earlier awakenings and reduced slow wave sleep [SWS]) that occur with increasing age.[3] Increased lighter stages of sleep, decreased slow-wave and REM sleep, and decreased total sleep time, sleep quality and sleep efficiency are other age-dependent changes in sleep frequently reported in older adults.[1,4] The biggest change in sleep patterns in older adults is the repeated and frequent interruption of sleep by long periods of wakefulness which could be because of the changes in circadian rhythm and homeostatic regulation of sleep occurring with age.[1,5,6] There are also changes in the neuroendocrine system with aging that alter sleep duration and sleep-wake cycles in older adults.[7] However, age itself is not a sole cause for poor sleep in older adults.[8] Decreased ability to maintain sleep in older adults is also commonly secondary to medical and psychiatric comorbidities and medications use to treat these disorders.[8,9] In addition,

insomnia, obstructive sleep apnea (OSA), and restless legs syndrome (RLS) are primary sleep disorders that can exacerbate sleep difficulties in older adults.[1] Besides these factors, changes in social patterns (e.g., retirement) have been identified to be associated with sleep quality in older adults.[10]

1.2 Poor Sleep Quality in Older Adults

Sleep complaints are common in older adults.[11,12] Approximately 50% of independently living older adults aged 65 years or older in the United States reported a sleep complaint.[11] Moreover, older adults are often dissatisfied with the quality of their sleep.[13]

Sleep quality is an important clinical construct since complaints about sleep quality are common and it is a common symptom of many sleep and medical disorders.[14] According to Buysse who developed a validated tool to measure sleep quality, sleep quality is defined as "quantitative aspects of sleep such as sleep duration, sleep latency, or number of arousals, as well as more purely subjective aspects, such as depth or restfulness of sleep".[14] Studies have used the terms sleep problems, sleep disturbance, difficulty sleeping, poor sleep, or poor sleep quality interchangeably. Sleep problems primarily include nighttime sleep problems (e.g., trouble falling asleep, trouble with waking during the night, trouble waking and getting up in the morning, and trouble waking too early and not being able to fall back to sleep).[15] Daytime sleepiness and poor quality of sleep are also considered sleep problems.[15]

Poor sleep quality results in significant mortality and morbidity in elderly individuals. Studies have reported that older adults with sleep disturbances had poorer quality of life and higher rates of depression and anxiety compared with those with no sleep disturbances.[3,9,16]

Cognitive impairment was shown in older adults with sleeping difficulties compared with those with no difficulties.[17] Additionally, poor sleep quality is related to decreased psychomotor function.[18] Overall, the consequences of poor sleep are deleterious in older adults.

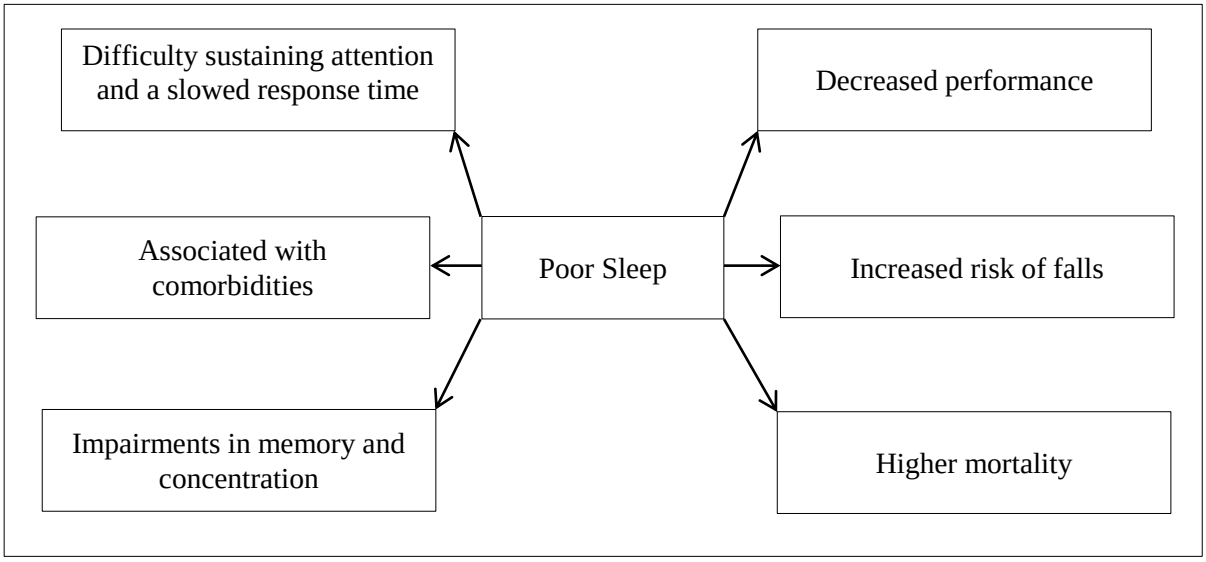

Figure 1.2 Consequences of Poor Sleep

1.3 Nonpharmacologic Treatments to Aid Sleep

There are nonpharmacologic interventions to aid sleep such as cognitive behavioral therapy (CBT).[19,20] CBT includes stimulus control therapy, sleep restriction, relaxation therapies, and cognitive therapies. Sleep hygiene measures are recommended to those who report having sleep disturbances. It is recommended that behavioral therapies and education on good sleep hygiene be included in treatment plans for disordered sleep in older adults.[8] The following are some interventions of good sleep hygiene.[1,20]

(1) Keep a regular sleep schedule by having stable bedtimes and rising times.

(2) Avoid sleep-fragmenting substances (e.g., caffeine, cigarettes, and alcohol).

(3) Go to bed only when sleepy.

(4) Maintain the bedroom restful and comfortable.

(5) Avoid napping after 2 pm and heavy exercise within 2 hours of bedtime.

(6) Increase activity level in the afternoon or early evening by exercising or walking.

(7) Sleep only in the bedroom and avoid activities in the bedroom that wake you up.

1.4 Medications Prescribed for or Used by Older Adults to Aid Sleep

The consumption of medications to aid sleep (e.g., sedative hypnotics) is common in older adults.[21] Because of decreased satisfying or refreshing sleep, older adults use a disproportionately high percentage of prescription drugs compared with other age groups to treat these complaints.[22] The 2003 National Sleep Foundation poll found that about 20% of older adults used some kind of sleep aid including prescription medications, over-the-counter sleep aid, and alcohol to help with sleep at least a few nights per week: 11% reported taking a prescription medication, 6% took an over-the-counter medication, and 6% used alcohol.[23,24]

Pharmacological treatments that are commonly prescribed to older adults with disturbed sleep include prescription medications (e.g., benzodiazepines, benzodiazepine receptor agonists, melatonin receptor agonists, antidepressants, antipsychotics and antiepileptics), nonprescription sleep aids (e.g.,antihistamines), herbal products/dietary supplements, and alcohol.[20,22] The first orexin receptor antagonist, suvorexant, was recently approved by the U.S. Food and Drug Administration (FDA) for treating difficulty in falling and staying asleep.[25]

<u>Prescription medications</u>:

Benzodiazepines: Benzodiazepines (e.g., triazolam, temazepam, flurazepam, alprazolam,

clonazepam, and lorazepam) promote sleep onset. These medications enhance the action of γ - aminobutyric acid (GABA) which causes sedation.[26] In 2006, benzodiazepines were the most commonly prescribed medications to treat sleep disorders in older adults.[27] Adverse events include hangover effects, impaired psychomotor performance and cognitive function.[18,22]

Benzodiazepine receptor agonists: Benzodiazepine receptor agonists include zaleplon, zolpidem, and eszopiclone. These nonbenzodiazepines have similar effects to benzodiazepines by binding to specific subtypes of the GABA-A receptor.[28] Zolpidem reduces sleep latency, improves total sleep duration, and reduces night-time awakenings.[29] Common adverse events during short term treatment (i.e., 10 days) are drowsiness, dizziness, and diarrhea, and during the long-term treatments (28-35 days), dizziness and drugged feelings are frequent.[19] Zaleplon has a fast onset of action and the shortest duration of action among the benzodiazepine receptor agonists.[19] Because of its short half-life, it has less morning hangover; however, it also has increased risk of rebound insomnia.[19] Eszopiclone is a stereoisomer of zopiclone. It is used when patients have difficulty falling asleep or difficulty maintaining sleep. It has been shown to reduce the time to sleep onset and enhance the quality and depth of sleep compared with placebo.[30] The most common adverse events of eszopiclone in older adults are headache, unpleasant taste, somnolence, and dysepepsia.[31]

Melatonin receptor agonist: Ramelteon is a selective melatonin receptor agonist with affinity for MT1 and MT2 receptors.[22] It received FDA approval for patients with difficulty falling asleep.[32] It has low risk of side effects,[22] including rebound insomnia and withdrawal effects.[32] Ramelteon did not show adverse next-day psychomotor or cognitive effects in older adults.[33]

Antidepressants: Antidepressants are also used to treat disturbed sleep in older adults.[22] Tricyclic antidepressants (e.g., amitriptyline and doxepin), and heterocyclic antidepressants (e.g.,

trazodone and mirtazapine) are the most commonly used sedating antidepressants.[34] These medications have sedating effect due to their anticholinergic and antihistaminergic effects.[34] Although commonly used, antidepressants antihistaminergic, antiadrenergic and anticholinergic side effects.[35] Trazodone has side effects of daytime drowsiness and dizziness that could be detrimental to older adults leading to accidents.[22]

Antipsychotics: Antipsychotic medications (e.g., quetiapine and olanzapine) are often used off label for sleep because of sedating side effects.[22,34] Antipsychotics are mostly used in individuals with serious psychiatric disorders.[22,34] Side effects can be disturbance of continuity of sleep resulting from nocturnal myoclonus.[36] Although antipsychotics can be beneficial in patients with psychiatric disorders, use may be harmful for healthy populations.[37,38]

Antiepileptics: Antiepileptics (e.g., gabapentin and tiagabine) are increasingly used to treat poor sleep in the elderly.[22,37] Tiagabine is a selective GABA reuptake inhibitor that enhances sleep.[37] Gabapentin reduces neurotransmission in glutamate and norepinephrine systems that regulates wake-promoting activity.[37] However, the effects on other sleep properties vary among patients after taking this drug.[37] Common antiepileptic side effects are ataxia, diplopia, and nausea.[26]

Nonprescription medications:

Antihistamines: Diphenhydramine and doxylamine are the most common antihistamines used for sleep in older adults.[20,22] Antihistamines can cause cognitive impairment, daytime drowsiness, and anticholinergic side effects (e.g., dry mouth, constipation, and blurred vision).[22] Most of all, there is insufficient data to show clinical effectiveness on sleep in older adults.[20,22]

Herbal products/Dietary supplements:

Other pharmacologic treatments taken to aid sleep include herbal sleep products and dietary supplements.[20,22] Several herbal products are available for treating sleep problems: valerian, chamomile, kava-kava, and passion flower.[22] There is lack of evidence or mixed evidence to support the safety and efficacy of most herbal sleep aids in older adults.[20] Melatonin is a hormone related to the sleep-wake cycle in humans. Melatonin supplementation is used to treat sleep problems related to jet-lag or shift work.[19] Side effects experienced by patients when taking melatonin include fatigue, headache, dizziness, and increased irritability.[19]

Alcohol:

Alcohol is widely used by older adults to aid sleep; however, it has negative effects on sleep.[20] Alcohol can disrupt sleep by decreasing latency of sleep onset and REM sleep and increasing SWS.[20] During the second half of the night, REM sleep rebound and sleep fragmentation may occur.[39]

Conclusion:

Poor sleep quality is common among older adults. Of the consequences of poor sleep quality, the risk of falls is the focus of this study. It is reasonable to expect that poor sleep quality might be a risk factor for falls since lack of sleep may cause daytime sleepiness, cognitive deficits, and reduced psychomotor performance that may lead to increased risk of falls.[40] In addition, older adults who have poor sleep could experience falls secondary to increased activity

during the night in darkness.[15]

Older adults use various medications and treatments to aid sleep. However, there are few randomized controlled studies that assess the efficacy and safety of these medications in older adults compared with younger adults.[22] Even though guidelines recommend short-term and low-dose use with short half-life sedative hypnotics in older adults, these medications are often used for extended periods.[41] The main adverse effects of pharmacologic treatments are daytime sleepiness, confusion and cognitive impairment, dizziness, and impairment of coordination and psychomotor functions, which may further relate to falls in older adults.[35]

The next section will provide a literature review on falls, the association between sleep medications and falls, and the association between poor sleep and falls in community-dwelling older adults. A review of literature will show some gaps on the combined effect of sleep medication use and poor sleep on the risk of falls.

Chapter 2

Literature Review

The purpose of this section is to review the literature to determine the prevalence of falls in older adults, and to assess the relationship between medications to aid sleep and falls, and between poor sleep and falls in older adults. This will help us to better understand what is already known about the association between poor sleep, sleep medication use, and falls in older adults.

2.1 Falls in Community-Dwelling Older Adults

Falls in older adults:

Falls are among the most common and serious problems faced by older adults. About 30% of community-dwelling adults aged 65 years or above experience a fall per year and about 15% of them fall two or more times per year.[42,43] In addition, 50% of adults aged 80 years and older fall at least once a year.[44,45] Falls cause both fatal and nonfatal injuries. Falls are associated with reduced functioning, loss of independence and premature nursing home admissions.[46,47] Specifically, falls are the primary reason for 85% of all injury-related hospital admissions[48] and for more than 40% of nursing home admissions.[49] According to the Centers for Disease Control and Prevention about 2.4 million older adults were treated in hospital emergency departments (ED) for nonfatal injuries from unintentional falls, resulting in more than 655,000 of these patients being hospitalized in 2012.[50] The death rates because of falls have risen over the past

decade with approximately 22,901 older adults dying from unintentional fall injuries in 2011.[50] Unsurprisingly, falls increase the cost of care. The total direct medical cost due to fall-related care for the non-institutionalized elderly population was $7.8 billion in 2002 and increased up to $19 billion in 2006 including institutionalized older adults.[51,52] A total cost of fall-related injuries in older adults is projected to be $47 billion in 2010 dollars by the year of 2020.[53] The cost is even higher if indirect costs associated with loss of productivity from falls in this population are considered.[51]

Definition of falls:

Various definitions of falls have been proposed. The World Health Organization (WHO) defines a fall as "an event which results in a person coming to rest inadvertently on the ground floor or other lower level".[54] The Prevention of Falls Network Europe (ProFaNE) group defined a fall as "an unexpected event in which the participant comes to rest on the ground, floor, or lower level".[55] Other similar definitions are provided by the Kellogg International Working Group and Frailty and Injuries Cooperative Studies of Intervention Techniques (FICSIT).[56] The variations in the definition of falls may cause comparability issues among the studies.

Risk factors for falls:

The risk of falls is multifactorial[46] and risk can be categorized as modifiable and non-modifiable factors.[57] Impaired vision, impaired balance and mobility, orthostatic hypotension, fear of falling, mood disorder, osteoporosis, incontinence, and polypharmacy are considered as modifiable risk factors, while age, gender, and race are non-modifiable risk factors.[57,58] Previous falls, medications, and reduced strength, gait and balance are most strongly associated with the

risk of falls.[59] A meta-analysis that included prospective studies assessing the risk factors in community-dwelling older adults was conducted.[60] It found that a 5-year increase in age, being female, living alone, having a history of falls, having a physical disability, experiencing disability in instrumental activities of daily life (IADL) and using a walking aid are associated with increased risk of falling.[60] Cognitive impairment, depression, history of stroke, urinary incontinence, rheumatic disease, vertigo, diabetes, pain, Parkinson's Disease, and fear of falling are other factors associated with falls in older adults.[60] Increment of one medical condition and self-perceived health status are also associated with falls. Additionally, gait problems, vision and hearing impairment are shown to increase the risk of falls.[60]

Assessment of falls:

Various fall assessment measures are used in different settings (e.g., outpatient clinic, inpatient or home).[61] First, clinician-rated scales are formalized questionnaires conducted by clinicians who use a semi-structured or structured interview to collect data. Self-report assessments mainly rely on a patient's recall of the events. Single task assessments are a more targeted tool to assess balance or gait disturbances that increases the fall risk. Lastly, multiple-task performance measures, a more comprehensive assessment of falls risk, can be used and provide more detailed information.

According to the American Geriatrics Society (AGS) and the British Geriatrics Society (BGS) Guideline for Prevention of Falls in Older Persons, multifactorial fall risk assessment is recommended for older adults who present with a fall or have gait and balance problems.[46] Multifactorial fall risk assessment that AGS/BGS guidelines included are: history of falls,

medications, gait, balance and mobility, visual acuity, other neurological impairments, muscle strength, heart rate and rhythm, postural hypotension, feet and footwear, and environmental hazards.[46]

2.2 Medications to Aid Sleep and Falls in Community-Dwelling Older Adults

Several studies have investigated the relationship between sedative hypnotics and falls in the adult population. A meta-analysis that included sedative hypnotics (i.e., benzodiazepines, zolpidem, zaleplon, zopiclone, antihistamines, and diphenhydramine) reported that the subjects using these medications had a higher incidence of falls.[21] The risk of psychomotor adverse events in those who take sedative hypnotics was higher than a placebo group but it was not significantly different than placebo (OR=2.61; 95% CI=1.12-6.09).[21] Another meta-analysis that evaluated the impact of nine medication classes on falls in older adults found that sedatives and hypnotics, (OR=1.47; 95% CI=1.35-1.62), antidepressants (OR=1.68; 95% CI=1.47-1.91), and benzodiazepines (OR=1.57; 95% CI=1.43-1.72) were significantly associated with falls.[62] A recent meta-analysis by Bloch and colleagues found antidepressants (OR=1.44; 95% CI=1.31-1.59), benzodiazepines (OR=1.31; 95% CI=1.16-1.47), and hypnotics (OR=1.40; 95% CI=1.24-1.58) were significantly related to any falls in adults aged more than 60 years old.[63] These results were similar to the previous meta-analysis.[62] Overall, these studies suggest that some medications frequently used to aid sleep have an association with falls in older adults.

Several mechanisms have been proposed to explain the relationship between falls and use of sedative hypnotics. Some of the adverse effects of sedative hypnotics (i.e., daytime sedation, drowsiness, and dizziness) may lead to falls.[64–67] Sedative hypnotics can also impair posture,

reaction time, coordination, protective responses during falls, and cardiovascular reflexes that normally prevent orthostatic hypotension.[64–67] The following section will describe the available literature regarding the relationship between the use of each type of medication used to aid sleep and the risk of falls in community-dwelling older adults.

Prescription medications:

Benzodiazepines: Benzodiazepines can impair motor function and coordination in older adults that may result in falls and consequent fractures.[22] There is consistent evidence of an increased risk of falls associated with benzodiazepines use in older adults.[62,68,69] A prospective cohort study that included community-dwelling women aged 65 years and older were followed incident falls for 1 year. It found that participants using benzodiazepines (OR=1.51; 95% CI=1.14-2.01) are at increased risk of falls after adjusting for multiple confounders.[69] This study clearly defined a fall as "falling all the way down to the floor or ground, or falling and hitting an object like a chair or stair".[69] Additionally, an observational study that included community-dwelling frail older adults defined the fall event as " a sudden loss of balance causing the contact of any part of the body above the feet with the floor" and it had to happen within 90 days of the evaluation.[70] It found that those who take benzodiazepines had an increased risk for falling (OR=1.36; 95% CI=1.08-1.71) after adjusting for potential confounders.[70] The authors also found a high risk of falls in patients using long elimination half-life benzodiazepines (OR=1.45; 95%CI=1.00-2.19) and short-elimination half-life benzodiazepines (OR=1.32; 95% CI=1.02-1.72).[70] Lastly, a prospective nested case-control study that examined the association between benzodiazepine use and injurious falls found that in subjects who were 80 years and older, the usage of

benzodiazepines was significantly associated with injurious falls (OR=2.22; 95% CI=1.44-3.43), while those under 80 years old had a non-significant increase.[71] Injurious falls were defined as "falls causing hospitalization, fractures, head trauma or death".[71]

Benzodiazepine receptor agonists: The relationship between the risk of falls and benzodiazepine receptor agonists was assessed in community-dwelling older adults, but it was not found to be significant.[70] On the contrary, a retrospective study in inpatient older adults showed that zolpidem (OR=2.63; 95% CI=1.04-5.43) was significantly associated with increased risk of falls.[72] In addition, a retrospective study that included hospitalized older adults concluded that zolpidem was a significant risk factor for falls (OR= 2.59; 95% CI=1.16-5.81) after adjusting for calcium channel antagonists and meprobamate, that are other medications significantly associated with a risk of falls.[73] Benzodiazepine receptor agonists were found to have negative effects on balance, gait, and equilibrium which can lead to falls.[67]

Melatonin receptor agonist: Ramelteon is reported to improve latency to persistent sleep and total sleep time in adults with transient and chronic insomnia and in older adults with chronic insomnia; however, there is no evidence of next-day residual cognitive and psychomotor effects.[74,75] No study has been conducted to assess the relationship between falls and ramelteon.

Antidepressants: Antidepressants may cause falls through sedation, impaired reaction time and balance, sleep problems resulting in daytime drowsiness and increased nocturia, orthostatic hypotension, disorders of cardiac rhythm, or a movement disorder.[76] Tricyclic antidepressants (TCAs) and selective serotonin reuptake inhibitors (SSRIs) may have a significant association with falling via postural hypotension caused by anticholinergic side effects, extrapyramidal effects and sedation.[77,78] A prospective study with community-dwelling older adults, found that

antidepressant use (OR=1.54; 95% CI=1.14-2.07) was associated with an increased risk of experiencing falls.[69] Another population-based prospective longitudinal study that included adults aged 70 years or older evaluated the association between depression, antidepressants, and falls.[79] Fall was defined as "unintentionally coming to rest on the floor, ground, or other lower surface in this study.[79] Antidepressant use significantly increased the risk of falls including indoor and outdoor falls when considering depression in the relationship (IRR=incidence rate ratio=1.50; 95% CI=1.11-2.03).[79] Lastly, a study that included men aged 60 to 75 years old found that antidepressants were significantly associated with at least one fall (OR=2.80; 95% CI=1.9-4.1) after adjusting for age, body mass index, current smoking status, and alcohol.[80] The data was from a 10-year prospective population-based study. It further analyzed and found that SSRIs (OR=3.10; 95% CI=2.0-5.0) and TCAs (OR=2.20; 95% CI=1.0-4.7) are associated with falling in fallers with at least one fall.[80] In contrast, another study with community-dwelling older adults did not find any significant association between antidepressants and falls.[70]

Antipsychotics: Typical and atypical antipsychotic medications are related to an increased risk of falls[62] that may be via extrapyramidal side effects, sedation or orthostatic hypotension.[77] An observational study with community-dwelling older adults found a higher risk of falling in those who use typical antipsychotic drugs (OR=1.49; 95% CI=1.10-2.51) and atypical antipsychotic drugs (OR=1.45; 95% CI=1.00-2.11) after adjusting for age, sex, activities of daily living (ADL) score, cognitive performance scale score, depression, comorbidity, number of medications, foot problems, gait problems, fear of falling and wandering.[70] In contrast, another study found that older men on antipsychotics were not found to have an increased risk of falls.[80] However, this study may not have had enough participants who took antipsychotics resulting in insufficient power to detect an association.

Antiepileptics: Antiepileptics may be associated with falls secondary to common adverse effects (e.g., sedation, dizziness, and unsteady gait).[69,81] A prospective study that was conducted in women aged 50 to 79 years old showed that users of antiepileptics had an increased risk of two or more falls (HR=1.62; 95% CI=1.50-1.74) after adjusting for multiple confounders compared with non-users.[81]

Nonprescription medications:

Antihistamines: Diphenhydramine and doxylamine can cause cognitive and psychomotor functioning impairment,[34,35] that may be associated with risk of falls in older adults.[82] Studies have emphasized that antihistamines should be used in caution in older adults[34,35] because of daytime drowsiness and anticholinergic effects.[20,22]

Herbal products/Dietary supplements:

A randomized placebo-controlled trial investigated the effect of olfactory stimulation with lavender on fall prevention in elderly individuals in nursing homes.[83] Interestingly, the group treated with lavender patches had fewer fallers (HR=0.57; 95% CI=0.34-0.95) and a lower incidence rate of falls (1.04 per person-year) compared with the placebo group. The authors speculated that lavender may have a soothing effect to reduce agitation and stabilizing effects on balance to prevent falls. No other studies conducted in community-dwelling older adults to evaluate the association between herbal products or dietary supplements and falls were identified.

Alcohol:

Alcohol can potentially raise the risk of falls by adversely affecting reaction time, judgment, or balance in older adults,[84] however, alcohol's association with falls is less clear in this population.[85] A prospective cohort study with community-dwelling older men found that light alcohol drinkers (≤13 drinks/week) had a lower risk of two or more falls in the first year of follow-up compared with those who did not drink alcohol (RR=0.77; 95% CI=0.65-0.92).[86] This suggested a protective association. However, the study found that moderate to heavy drinking (≥14 drinks/week) was not associated with a risk of falls.[86] Another prospective cohort study in community-dwelling older adults found no difference between non-drinker and light-to-moderate drinkers (≤14 drinks/week) on risk of falls, but found a significant increase risk of falls in heavy drinkers (14 or more) during the follow-up of 4 years (OR=1.25; 95% CI=1.03-1.52) compared with non-drinkers after adjusting for multiple confounders.[87] Similarly, another study showed that high alcohol consumption (500+g/month) was significantly associated with injurious falls in women aged 60 years or older (OR=2.13; 95% CI= 1.05-4.32).[88] Overall, these studies were conducted in community-dwelling older adults; however, findings about the association between alcohol consumption and falls in this population are inconsistent.[89]

Conclusion:

There were several limitations of the studies that were included in this review. First, systematic literature reviews and meta-analyses had consistent results that the use of sedative hypnotics, benzodiazepines, and antidepressants increase the likelihood of falls in older adults. However, there was conflicting results or no results with nonprescription medications, herbals

and alcohol on the association with falls in community-dwelling older adults. These reviewed studies did not specifically mention which medications were included in each drug classification, thus it is difficult to assess whether the majority of medications are frequently used to aid sleep.

In addition, methods of ascertaining medication use were different among the studies. In some studies participants were asked to bring the medications that were used, while others collected information directly from general practitioners or through medical records. Studies have defined the outcome of falls with different definitions, and most studies did not even report how they defined the outcome. Additionally, studies had different methods to document falls (e.g., using diaries, post cards, or phone calls). These differences in the studies make it more difficult to directly compare the results across studies.

Most of all, confounding by indication in the association between sleep medication use and falls can occur but the indications for these medications were not clearly mentioned. Yet given that these medications are frequently used for sleep and that the results of systematic literature reviews and meta-analyses are consistent with each other, it is important to consider that sleep medications could be the main risk factors for falls.

2.3 Poor Sleep and Falls in Community-Dwelling Older Adults

One important and potential risk factor for falls that has not been investigated in most studies is poor sleep in older adults.[15] To date, there has been no systematic review integrating studies that evaluated the association between sleep problems and risk of falls in older adults. Therefore, we conducted a systematic review of the literature to investigate the association between sleep problems and falls in community-dwelling adults aged 65 years or older. This will help to

elucidate whether sleep problems are a significant risk factor for falls in independently living older adults.

2.3.1 Methods:

The review was conducted based on the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines.[90]

Eligibility Criteria:

Studies were included if they met the following criteria:

1) Studies that evaluated poor sleep or other types of sleep problems as an independent predictor variable and the occurrence or number of falls or the risk of falls as an outcome variable.

2) Studies that included community dwelling adults aged 65 years old or older. Community-dwelling older adults are non-institutionalized older adults who live independently.

3) Studies that were published in English.

4) Studies that were published in a peer-reviewed journal.

Studies were excluded if they met the following criteria:

1) Studies that included only specific sub-populations of older adults with specific health conditions (e.g., Parkinson's diseases or dementia).

2) Studies that were reviews, commentaries, case-reports, case-studies or newsletters.

Information sources:

A systematic search of studies from major databases was conducted from inception until

December 31, 2013. The search was applied to Pubmed/MEDLINE (1946-2013), CINAHL (1937-2013), and PsycINFO (1887-2013) to identify relevant studies. Restrictions were applied to limit the search to studies in English. The last search was conducted in January 30, 2014. In addition, the grey literature was searched to find non-conventional publications through The New York Academy of Medicine (NYAM) (1992-2013).

Systematic search strategy:

MeSH terms and text words of sleep problems and falls were used: ("Sleep"[Mesh] OR "Sleep Disorders"[Mesh] OR "Sleep"[tw] OR "sleep disorders"[tw]) AND ("Accidental Falls"[Mesh] OR "Falls"[tw]). Similar search terms were used for CINAHL and PsycINFO. Quick search of the database for the grey literature through NYAM with a combination of "healthy aging fall" and "prevention fall" was conducted. See appendix A for the search algorithm.

Study selection:

Eligibility assessment was performed in a standardized manner by the first author. In the first phase of the review, the reviewer independently reviewed the titles and the keywords of the articles. Studies that included the terms "sleep" or "falls" or "older adults/elderly" within a title or keyword were retained for further review of the abstracts. In the second phase of the review, abstracts were reviewed to determine whether the full texts should be reviewed. In the last phase of the review, full texts were read and if there was any doubt after reviewing the full texts, the second author determined whether the articles would be included in the final inventory of studies.

Data collection:

Data extraction was conducted by one reviewer but reviewed multiple times to reduce error. The data included study design, year of publication, location, study population, study duration, sample size, measurement of sleep problems (a predictor variable), measurement of falls (an outcome variable), adjusted covariates, and association statistics (e.g., odds ratio with 95% confidence interval and p-value).

Methodological quality assessment:

The Newcastle-Ottawa Scale (NOS) was used to assess the methodological quality of the studies. NOS is recommended by the Cochrane Collaboration as one of the most useful tools to evaluate non-randomized studies and it is simple to apply.[91] The scale is used to judge the selection of the groups, the comparability of the groups, and the ascertainment of the exposure and the outcome of interest.[91] The NOS was originally developed to assess only case-control and cohort studies.[92] Since ten out of fifteen of the reviewed studies were cross-sectional studies, an adapted form of NOS for cross-sectional studies developed by Herzog et al. was applied.[93] The maximum score is 9 for cohort studies and 10 for cross-sectional studies. The scores were predicted to be low and similar across the studies because most studies have assessed the predictor and outcome variables by self-report. Results are shown in Table 2.2 and 2.3.

Summary measures:

To evaluate the association between sleep problems and falls, association statistics were reported as well as 95% confidence intervals. Adjusted association was the main statistic reported, but various confounding variables were adjusted across the studies.

2.3.2 Results:

Study selection:

Figure 2.1 shows the flow diagram of studies included in the systematic review. A total of 490 studies were retrieved from PubMed, 200 studies from CINAHL, and 17 from PsycInFO. An additional seven studies were retrieved from the NYAM search of grey literature. One hundred and thirty-two studies were identified as duplicates. After the titles, key words, and abstracts were reviewed, 37 articles were included in the full text reviews. Twenty-two studies were excluded with reasons at the full text reviews: studies that were reviews, commentaries, or case reports, studies that did not assess an outcome of falls or the association between sleep problems and falls, and studies that only reported results for the general population with absence of a separate analysis for older adults. A total of 15 original research studies were included in this review.

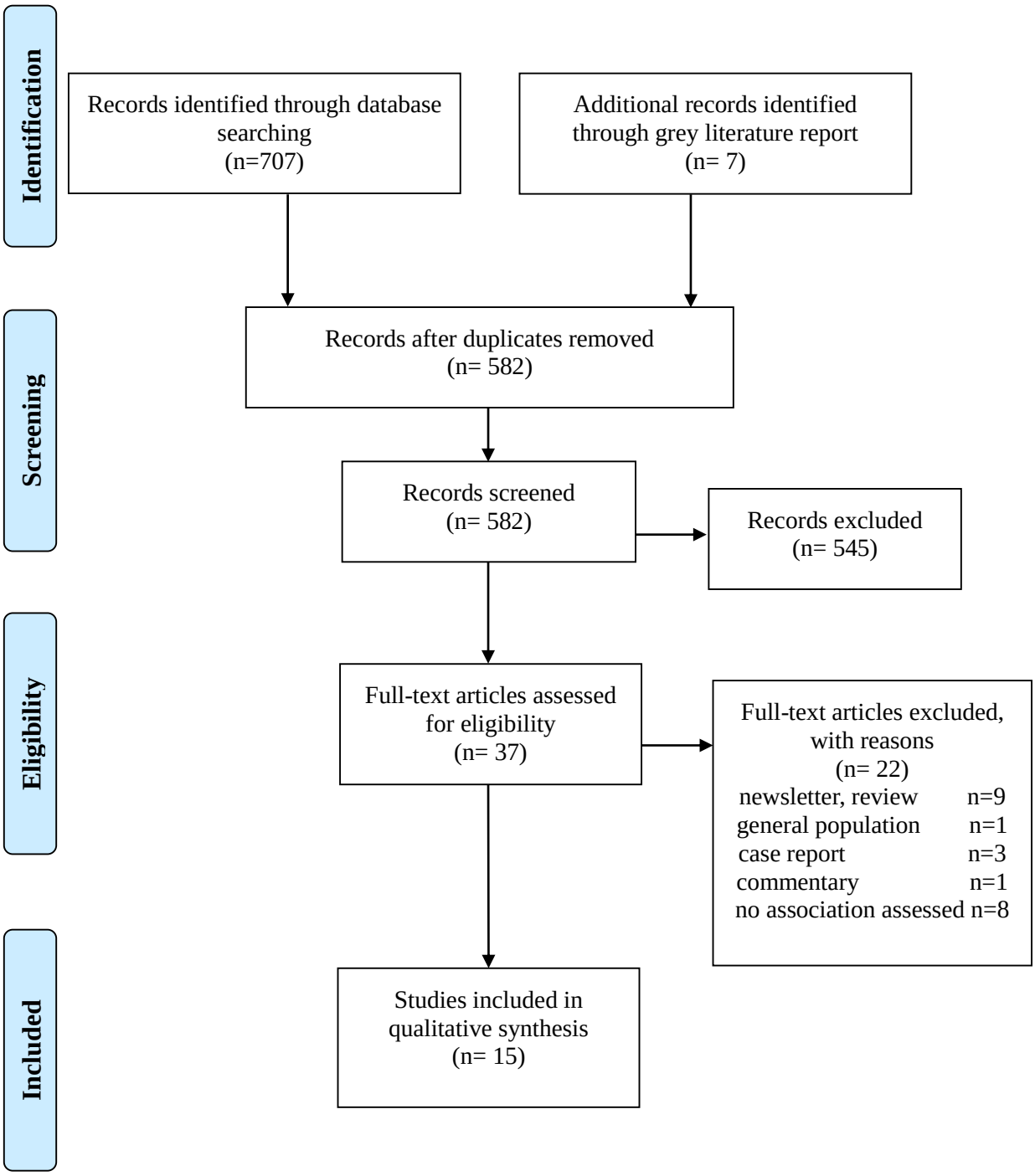

Figure 2.1 PRISMA Flow Diagram for Search Strategy[90]

Study characteristics:

Out of fifteen studies, ten studies were cross-sectional studies while five studies were prospective cohort studies. Thirteen studies included only community-dwelling older adults, while the other two studies included both institutionalized and community-dwelling older adults. The studies were conducted primarily in the U.S. and Australia. The predictor variable "sleep problems" was primarily collected by self-report or validated questionnaires. The most common questionnaire used was the Epworth Sleepiness Scale (ESS) which is a measure of daytime sleepiness. The outcome variable "falls" was collected by self-report either as a fall in the past 6 or 12 months. Table 2.1 provides a description of each study. The findings are organized by type of sleep problems evaluated.

Nighttime sleep problems and falls:

Several studies investigated whether nighttime sleep problems have an association with falls in older adults. Brassington et al.[15] examined whether nighttime sleep problems are risk factors for falls. The investigators assessed habitual nighttime sleep difficulties by rating on a self-reported scale. Compared with non-fallers, fallers had problems of nighttime sleep (i.e., falling asleep at night, waking up during the night, waking up in the morning and waking up too early in the morning and not being able to fall asleep again). After adjusting for covariates including use of prescription medication, difficulty falling asleep at night (OR=1.53; 95% CI 1.04-2.24), waking up during the night (OR=1.91; 95% CI=1.44-2.54), waking up in the morning (OR=2.13; 95% CI=1.28-3.55) and waking up too early in the morning and not being able to fall asleep again (OR=1.64; 95% CI=1.11-2.42) were significantly associated with the occurrence of falls.[15] In addition, nighttime sleep problems, except for waking up too early in the morning and

not being able to fall asleep again were significantly associated with the number of falls. Most nighttime sleep difficulties had a significant association with the occurrence and the number of falls while controlling for other covariates. However, this study was a cross-sectional study and validated questionnaires were not used to assess the sleep problems. The study by Helbig et al.[94] evaluated the relationship between sleep disturbances (i.e., trouble falling asleep and trouble staying asleep, and falls). The odds of falls were higher in older adults who had trouble staying asleep and trouble falling asleep. However, these sleep problems were significantly associated with falls only in adults over 75 years of age.[94] This might be because of differences in the level of frailty between younger old (i.e., between 65 and 75 years old), and older and oldest old (i.e., more than 75 years of age).

In contrast to these findings, a cross-sectional study by Teo et al.[95] found no significant increase of risk of falls due to the same nighttime sleep problems after adjusting for covariates. This was in agreement with a prospective study by Byles et al.[96] that showed that none of the nighttime sleeping problems were associated with falls after adjusting for covariates. Although both studies by Brassington et al.[15] and Teo et al.[95] evaluated the same categories of nighttime sleep problems and used the same scale of 1 (never) to 5 (always), they had conflicting findings. The study by Byles et al.[96] asked about different aspects of nighttime sleep problems and used a different scale of responses. Byles et al. defined sleep problems as waking up in early hours, lying awake for most of the night, taking a long time to get to sleep, sleeping badly at night, and having worry that keeps them awake at night. Unfortunately, detailed results of the association between each nighttime sleep component and falls were not reported.[96]

Differences among the studies may contribute to the inconsistent findings. Some studies only included community-dwelling older women,[95,96] while other studies included community-

dwelling older adults of both genders and with a broader range of age.[15,94] Furthermore, some studies adjusted for more variables, including medical status or medications, that could be related to falls to account for the effect of the confounders in an attempt to find the relationship between sleep problems and falls.[15,94]

Sleep quality and falls:

There were three studies that specifically evaluated the relationship between sleep quality and falls. The study by Hill et al.[97] determined whether sleep disturbances contribute to the risk of falling. The survey was conducted by interviews with older adults living in residential aged care and an internet-based survey was conducted in independent-living older adults. The same questions about sleep were asked to both groups, but only the results for internet study participants were included in this review, because those living in residential aged care facilities are semi-independent. Sleep characteristics evaluated were quality of sleep, duration of sleep, daytime alertness, napping during the daytime and nocturnal awakenings. The study found no association between any of the sleep characteristics and falls in internet response participants, but investigators were able to identify that those who had no sleep problems (14%) were less likely to fall (OR=0.3; 95% CI=0.1-0.9).[97] However, it is possible that internet respondents may not represent the general community-dwelling older adult population. A study by St George et al.,[10] which specifically asked about sleep quality in 169 residents from self-care units and assisted-care hostels, did not find an association between sleep quality and falls in either group. The results of the study were not reported separately for self-care units and assisted-care hostels participants, so there could have been different results in independent-living older adults alone.[10] Both studies did not define poor sleep quality and did not use a validated questionnaire to assess

sleep quality.[10,97] The study by Endeshaw[98] was the only study that used the validated Pittsburgh Sleep Quality Index (PSQI) to measure sleep quality. This study included approximately 250 participants and reported no significant relationship between poor sleep quality and falls. However, numerical results were not presented to support this conclusion. Interestingly, the study found that individuals with nocturia with difficulty going back to sleep were more likely to have falls (OR=4.32; 95% CI=1.51-12.42) than those without difficulty going back to sleep (OR=2.95; 95% CI=1.08-8.81).[98] Based on the studies that evaluated sleep quality and falls, poor sleep quality was not shown to be associated with the risk of falls, but this may be because of a lack of a consistent definition of sleep quality and the use of validated tools to measure it.

Daytime sleepiness and falls:

Daytime sleepiness, which is a feeling of being sleepy or struggling to stay awake in the daytime, was assessed in most of the selected studies. The study by Teo et al.[95] showed that daytime sleepiness increased the risk of falls twofold after adjusting for covariates of fall-related risk factors (OR=2.05; 95% CI=1.21-3.49). This study used the Epworth Sleepiness Scale (ESS) to measure daytime sleepiness, and the fallers scored 12.4 on the ESS compared with non-fallers who scored 5.7. An ESS score greater than 10 indicates abnormal daytime sleepiness. On the other hand, Brassington et al.[15] found that daytime sleepiness was significantly associated with the number of falls but not with the occurrence of falls. However, the investigators did not use a validated questionnaire to evaluate daytime sleepiness. Additionally, studies by Hill et al.[97] and Helbig et al.[94] found that daytime sleepiness was not significantly associated with falls in older adults. Significant results were not seen in adults age 75 years or above in the study conducted by Helbig et al.[94]

Two[95,97] out of the four studies evaluating daytime sleepiness as a risk factor used a validated questionnaire, the ESS, to measure daytime sleepiness in older adults.[15,94,95,97] Despite using the same measure, varying results were documented. The investigators Teo et al.[95] and Hill et al.[97] used the ESS to evaluate daytime sleepiness, while Brassington et al.[15] and Helbig et al.[94] asked a question about daytime sleepiness. Since the study by Hill et al.[97] did not provide detailed results for internet study participants, we cannot further investigate the differences between the studies by Teo et al.[95] and Hill et al.[97] Thus, it is difficult to conclude whether daytime sleepiness is significantly related to falls. To further investigate the relationship, more studies using a validated tool to measure daytime sleepiness are needed.

Sleep duration and falls:

Other sleep problems in older adults include short or fragmented sleep duration. Of the nine studies evaluating the risk of falls among individuals with varying duration of sleep, two[99,100] were prospective cohort studies and seven were cross-sectional studies.[10,15,94,97,101–103] The study by Mesas et al.[101] found that older adults who slept 11 hours or more per 24 hours had an increased risk of recurrent falls (i.e., two falls or more) compared with those who slept 7-8 hours (OR=2.75; 95% CI=1.32-5.62) even after adjusting for covariates. However, the association between sleeping less than 5 hours and falls was not significant after adjusting for covariates. A similar trend was seen between sleep duration and falls (i.e., one fall or more) in older adults. After stratifying by age and sex, sleeping 11 hours or more (OR=2.34; 95% CI=1.17-4.68) and sleeping less than 5 hours (OR=2.15; 95% CI=1.20-3.87) were significantly associated with falls only in adults older than 75 years of age.[101] In addition, women who had 11 hours or more of sleep had a significant risk of falls (OR=3.89; 95% CI=1.74-8.69) compared

with men.[101] This was the only study that stratified by age and sex that showed a higher risk of falls among adults aged 75 years or older and women aged 65 years or older. The study by Helbig et al.[94] categorized the duration of sleep as less than or equal to 5, 6, 7-8, 9, and greater than or equal to10 hours and found that only individuals without dizziness who slept 9 hours a day were more likely to fall (OR=1.47; 95% CI=1.03-2.11) after adjusting for all covariates. In the unstratified analysis, significant associations with other durations of sleep were found in a basic model that adjusted for age and sex but was not found in full models that adjusted for many covariates.

A third study by Kuo et al.[102] showed that there was a significant association between sleep duration of less than 5 hours and falls in women after adjusting for covariates (OR=5.98; 95% CI=1.72-20.85). The association between short sleep duration and falls was also significant after controlling for confounders in women who do not use any psychotropic medications (OR=9.04, 95%CI=1.44-56.84).[102] However, this association was not found in men. Similarly, St George et al.[10] found that older adults who slept less than 6 hours were three time more likely to have falls after adjusting for age, gender, psychotropic medication use, accommodation, activity and health status (OR=3.13; 95% CI=1.33-7.37). However, this study included older adults residing in an assisted living facility who may have a different profile of health characteristics and the investigators did not report the results separately for those who live independently.

Among the studies, Stone et al.[100] objectively measured sleep characteristics by using sleep actinography and found that sleeping less than 5 hours was significantly associated with recurrent falls compared with sleeping 7 to 8 hours (OR=1.52; 95% CI=1.03-2.24), however, there was no relationship between long sleep (8 or more hours) and risk of falls.[100] On the other hand, another study by Stone et al.[99] tested the relationship between self-reported sleep duration

and falls and showed that there was an increased likelihood of having two or more falls in women who reported sleeping more than 10 hours per 24 hours compared with those who reported sleeping between 8 and 9 hours (OR=1.50; 95% CI=1.14-1.97).[99] However, this was noted only in an age-adjusted model; a significant relationship was not found in the multivariate adjusted model. In addition, Brassington et al.[15] and Hill et al.[97] did not find a significant association between sleeping less than 8 hours a day with the occurrence and number of falls.

Lastly, a study by Grundstrom et al.[103] analyzed adults aged 85 years and above to evaluate the risk of falls in this aged population. One of the risk factors studied was days of perceived insufficient sleep, which represents the days when participants did not feel they got enough sleep or rest in the past 30 days. The days were categorized as 0, 1-7, 8-14, 15-22, and 23-30 days, but insufficient sleep over the last 30 days was not associated with a higher risk of falls in the past 3 months (OR=1.01; 95% CI=1.00-1.02).

Overall, these results suggest that older adults experiencing short duration of sleep (less than 5 hours of sleep) are at risk for experiencing more falls than those who sleep normal hours (between 7-8 hours). Long duration of sleep (more than 9 hours) as a risk factor remains controversial. Studies by Stone et al.[99,100] were the only studies that collected data prospectively, but they only included Caucasian/ White participants. Other studies were all cross-sectional in design so causality cannot be explained in the association. Except for the study by Stone et al.[100] sleep duration was subjectively measured that might result in bias. Moreover, studies used different categorizations of the duration of sleep, which contributes to variability and makes drawing conclusions difficult.

Napping and falls:

There is a correlation between the two sleep factors of sleep duration and napping in that people who sleep less at night also have longer naps during the day. Four studies investigated in detail whether napping during the day is a risk factor for falls.[10,15,99,100] St George et al.[10] found that napping more than 30 minutes significantly increases the risk of multiple falls (OR=3.10; 95% CI= 1.30-7.42) even after controlling for covariates. Residents of an assisted-care facility had more hours of napping than residents living independently. However, since results for these two categories of participants were not reported separately, the results for independent living older adults are not available.

The results were in agreement with Stone et al.[99] in which women who took daily naps were more likely to have two or more falls during the following year (OR=1.32; 95% CI=1.03-1.69). The authors also found that women who nap 3 hours or more per week have a significant increased risk of recurrent falls compared with those taking naps less than 3 hours per week (OR=1.33; 95% CI=1.10-1.60).[99] The second study by Stone et al.[100] measured naps using actigraphy and did not find any relationship between the risk of falls and napping. This might be attributed to using a different method of measuring napping. Actigraphy measures intentional and unintentional naps which could have measured more napping hours compared to measuring by self-report. Finally, a study by Brassington et al.[15] showed that napping during the day was a significant predictor of the number of falls even though it was not associated with the occurrence of falls. However, daytime napping was self-reported and the magnitude of the effect was small (*b*=0.17; 95% CI=0.01-0.34).[15]

Three[10,15,99] out of four studies found that napping during the day is significantly associated with falls.[10,15,99,100] Studies reported that older adults napping more than 30 minutes a

day or napping three hours or more per week have a significant risk of falling. The only study that did not find any association with falls used actinography to measure naps.[100] Considering the consistency of the results that used self-report as a measure of napping, older adults reporting daytime napping have a significantly increased risk of falls.

Sleep disorders:

Few studies have investigated the relationship between specific sleep disorders and falls. Gassmann et al.[104] evaluated potential predictors of occasional and recurrent falls in community-dwelling older adults in Germany. Diagnosis with a sleep disorder was found to be a significant predictor among occasional fallers with only one fall (OR=2.69; 95% CI=1.58-4.6) and recurrent fallers who had two or more falls (OR=2.96; 95% CI=1.44-6.06) during the past 6 months compared with non-fallers.[104] However, there was no further description or definition of sleep disorder provided, thus the effect of specific type or severity of sleep disorder could not be assessed.

A study by Kaushik et al.[105] evaluated whether sleep apnea is related to falls in older adults. Sleep apnea was assessed by self-reported diagnosis. Other sleep-related variables that were evaluated were snoring, whether participants had been told that they snore, witnessed apnea, whether participants had been told that they stopped breathing during sleep, and daytime sleepiness assessed by ESS. Sleep apnea was found to be significantly associated with two or more falls during the previous 12 months (OR=2.23; 95% CI=1.11-4.47) after adjusting for covariates.[105] No other sleep-related variables were found to be related to falls, however, quantitative results were not reported for these other variables.

Lastly, Cirillo and Wallace[106] evaluated whether restless legs syndrome is associated with functional limitations among American elders. Based on the Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition (DSM-5) criteria, restless legs syndrome is classified as a sleep-wake disorder. It is a tingling feeling in your legs and is often worse at night or when inactive. Two or more falls in the last 2 years were significantly associated with higher prevalence of restless legs syndrome (OR=2.63; 95% CI=1.49-4.66) but not with only falling once.[106]

Specific sleep disorders (e.g., sleep apnea, restless legs syndrome) were found to be significantly related to falls. Sleep apnea was defined by self-reported diagnosis and doubled the risk of experiencing a fall. In addition, people who fell two or more times had a higher prevalence ratio of restless legs syndrome. Odds ratio is an approximation to the prevalence ratio. The prevalence ratio of 2.63 for falling twice or more means that those with frequent falls had a 2.63 times higher prevalence of restless legs syndrome than those who did not fall. Sleep symptoms (e.g., problems with early awakening) were adjusted to focus specifically on the impact of restless legs syndrome on the risk of falls.

Table 2.1 Summary of Included Studies

Authors	Setting	Study population and sample size	Predictor variables	Outcomes	Adjusted variables
Brassington et al.[15] (2000)	U.S.	Community-dwelling older adults (971 female), age range 64-99 years old	Nighttime sleep difficulties (falling asleep at night, waking up during the night, waking up in the morning, waking up too early in the morning and not being able to fall asleep again) and alertness during the day (daytime sleepiness, nap during the day, and less than 8 hours of sleep)	Occurrence and frequency of falls in the past 12 months	Age, gender, use of prescription medication, difficulty walking, having greater than one chronic condition, vision impairment, and depression
Byles et al.[96] (2003)	Australia	Community-dwelling older adults (10,430 female), age range 70-75 years old	Sleeping difficulty (waking up in early hours, lying awake for most of the night, taking a long time to get to sleep, sleeping badly at night, and having a worry that keep awake at night)	Occurrence of falls in the past 12 months	Use of sleeping medications, symptoms, acute conditions, age, and life events
Cirillo and Wallace[106] (2012)	U.S.	Community-dwelling older adults, 1008 participants (578 female), age range 50-80 years old	Restless legs syndrome	Occurrence of one or more than one fall the last 2 years	Age, gender, income, current drinking status, body mass index (BMI), pain, number of chronic medications used, out of pocket medical expenses, frequency of doctors' visits in last 2 years, health limits ability to work, associated sleep problems
Endeshaw[98] (2009)	U.S.	Community-dwelling older adults, 123 participants (63 female), mean age 75.6 years old	Sleep quality and daytime sleepiness	Occurrence of one or more than one fall in the past 6 month	Age, gender, number of medications, cardiovascular/cerebrovascular disease status, use of sedative hypnotics, and nocturia status

Grundstrom et al.[103] (2012)	U.S.	Community-dwelling older adults, 12,684 participants (9036 female), age 85-95+ years old	Perceived insufficient sleep (number of days in the past 30 days when participants did not get enough sleep or rest)	Occurrence of falls and fall-related injury in the past 3 months	Age, gender, race, marital status, general health, activity limitation due to health problem, health problem requiring assistive devices, smoking, consume of alcohol, BMI, diabetes, history of stroke
Gassmann et al.[104] (2009)	Germany	Community-dwelling older adults, 622 participants (297 female), age range 65-90 years old	Sleep disorder	Occurrence of falls during the 6 months	Only bivariate associations were assessed
Helbig et al.[94] (2013)	Germany	Community-dwelling older adults 3875 participants (1998 female), age range 65-93 years old	Sleep habits (trouble falling asleep, difficulty staying asleep), daytime sleepiness, and sleep duration (≤5, 6, 7-8, 9, ≥10 hours)	Occurrence of falls in the previous 12 months	Age, sex, education level, leisure time, physical activity, multimorbidity, eye and neurological disease, depression and/or anxiety, psychotropic or antihypertensive medication, risk for malnutrition, disability, hearing impairment, and dizziness
Kaushik et al.[105] (2007)	Australia	Community-dwelling older adults, 1,952 people, age range 60-97 years old	Sleep apnea, other sleep-related variables (snoring and daytime sleepiness)	Occurrence of falls in the past one year	Age, female gender, history of stroke, presence of arthritis, visual impairment, use of sedative, phenothiazine, and antidepressant, depression and mental state
Kuo et al.[102] (2009)	Taiwan	Community-dwelling older adults, 256 participants (135 female), mean age 72.2 years old	Sleep duration (less than 5 hours, 5-7.9 hours, and 8 or more hours)	Occurrence falls in the past 12 months	Age, educational level, living alone, smoking, alcohol consumption, comorbid conditions and dieases (diabetes, hypertension, heart disease, arthritis, chronic lung disease, depressive symptom, and central obesity), use of medications (antihypertensives, antidepressants, sedatives, and antipsychotics), low-extremity function summary score, and cognitive impairment

Hill et al.[97] (2007)	Australia	150 hostel older adults (99 women), age range 81±8 and 150 community-dwelling older adults (85 female), age range70±5 years old	Daytime sleepiness, sleep quality, restfulness of sleep, duration of sleep, number of nocturnal awakenings	Occurrence of falls in the past 12 months	Age, depression, mobility (Timed Get Up and Go scores, and Snellen chart score) , pain, use of walking aids, use of diuretics
Mesas et al.[101] (2010)	Spain	Community-dwelling older adults, 1542 older adults (892 female), mean age 77.4±6.3 years old	Sleep duration (≤5, 6, 7-8, 9, 10, ≥11 hours per day)	Occurrence and number of falls in the past 12 months	Age, gender, education level, size of municipality, leisure-time physical activity, smoking, alcohol and coffee consumption, BMI, social ties, perceived health, Short Form 36 (SF-36) physical and mental summary, limitation in IADL, urine loss, depression, hypertension, diabetes, cancer, myocardial infarction, stroke, heart failure, dementia, Parkinson's disease, osteoporosis, snoring, nocturia, hip fracture or prosthesis, visual and hearing impairment, walking device, knee pain, sleeping pill consumption, difficulty falling asleep, frequent awakening during the night, early awakening, unrested in the morning, and daytime sleepiness
St. George et al.[10] (2009)	Australia	Older adults 440 from self-care units and 132 from assisted care-hostels, age range 62-95 years old	Sleep quality, sleep duration, restful sleep, waking condition, napping frequency, napping duration	Occurrence of falls in the past 12 months	Age, gender, psychotropic medication use, accommodation type, activity and health status

Stone et al.[100] (2008)	U.S.	Community-dwelling older women, 2978 female, age range 84±4 years old	TST, sleep efficiency, wake time after sleep onset, napping (termed daytime inactivity)	Occurrence of falls in the past 12 months	Age, race, BMI, depression, exercise, limitation in IADL, medical conditions, possible dementia, and use of benzodiazepines, antidepressants, and antipsychotics
Stone et al.[99] (2006)	U.S.	Community-dwelling older women, 8,101 female, age range 77±5 years old	Daily napping, number of hours of napping per week, and napping at least 3 hours per week, total daily duration of sleep	Occurrence of falls in past 12 months	Age, BMI, history of at least one medical condition, walk for exercise, alcohol consumption, depression, cognitive impairment, use of benzodiazepines and estrogen, and urinary incontinence
Teo et al.[95] (2006)	Australia	Community-dwelling older women, 782 female, age range 75-86 years old	Nighttime sleep disturbance (trouble falling asleep, with waking during the night, waking and getting up in the morning, waking too early and not being able to fall back asleep) and daytime sleepiness	Occurrence of one or more than one fall in the past 12 months	Age, Central Nervous System (CNS) drugs, Cardiovascular System (CVS) drugs, and nocturia

Table 2.2 Methodological Quality of Included Cohort Studies by Newcastle Ottawa Scale[92]

Study (first author)	Study design	Selection				Comparability		Outcome	
		Representativeness of the sample	Selection of the non-intervention cohort	Ascertainment of the exposure	Demonstration that outcome was not present at the start	Based on design or analysis	Assessment of outcome	Follow-up period	Follow-up cohort
Byles et al.[96] (2003)	Prospective cohort (3 years)	+		+		++		+	+
Gassmann et al.[104] (2009)	Prospective cohort (6 months)	+			+			+	
St George et al.[10] (2009)	Prospective cohort (1 year)			+	+	++	+	+	+
Stone et al.[100] (2008)	Prospective cohort (1 year)	+		+	+	++		+	+
Stone et al.[99] (2006)	Prospective cohort (1 year)	+			+	++		+	+

Table 2.3 Methodological Quality of Included Cross-Sectional Studies by Newcastle Ottawa Scale[93]

Study (first author)	Study design	Selection				Comparability	Outcome	
		Representativeness of the sample	Sample size	Non-respondents	Ascertainment of the exposure	Based on design or analysis	Assessment of outcome	Statistical test
Brassington et al.[15] (2000)	Cross-sectional	+	+	+	+	++	+	+
Cirillo & Wallace[106] (2012)	Cross-sectional	+			+	++	+	+
Endeshaw[98] (2009)	Cross-sectional	+			++	++	+	+
Grundstrom et al.[103] (2012)	Cross-sectional	+	+		+	++	+	+
Helbig et al.[94] (2013)	Cross-sectional	+	+		+	++	+	+
Kaushik et al.[105] (2007)	Cross-sectional	+				++	+	+
Kuo et al.[102] (2009)	Cross-sectional	+			+	++	+	+
Hill et al.[97] (2007)	Cross-sectional		+		++	++	+	+
Mesas et al.[101] (2010)	Cross-sectional	+	+	+	+	++	+	+
Teo et al.[95] (2006)	Cross-sectional		+		++	++	+	+

2.3.3 Discussion:

To our knowledge, this is the first systematic review to focus on the association between sleep problems and falls in community-dwelling older adults. Most of the studies that were included in the review explored this relationship as their primary objective. Based on this review, problems of nighttime sleep (e.g., trouble staying asleep, trouble falling asleep, short or long sleep duration, and napping) appear to be highly associated with the risk of falls. However, it is difficult to draw conclusions about causality because most of the studies were cross-sectional.

Thirteen out of fifteen studies accounted for medication use in assessing sleep problems and falls in older adults. Most studies mentioned specific classes or types of medications that were accounted for while only two adjusted for the prescription medication use or the number of medications used. Five studies clearly mentioned adjusting for sedative medications.[96,98,101,102,105] Two studies adjusted for psychotropic medications[10,94] which one of them clearly considered sedative hypnotics[94] and one study[95] adjusted for medications acting on the central nervous system (CNS). Two studies adjusted for benzodiazepines.[99,100] However, the magnitude of the fall risk associated with sleep problems with or without adjusting for these medications was not possible to compare in most of the studies. Additionally, other various covariates (e.g., chronic conditions) were adjusted for in the studies which changed the unadjusted associations. For example, studies by Stone et al.[99] and Helbig et al.[94] found that long duration of sleep increased the risk of fall in basic models, but significance was lost after accounting for various risk factors for falls. This may be because the mechanism of association is mediated by other risk factors for falls.

The association between sleep disturbances and falls can be explained by various mechanisms. Sleep disturbances may cause daytime sleepiness, impaired cognitive

performance, balance and gait problems, and slower response time.[23,40,107] In addition, it was frequently mentioned that poor sleep may cause cognitive dysfunction with memory and concentration problems.[17,97,108,109] All of these impairments are reported to be caused by poor sleep that may increase the likelihood of falls. Results of the current systematic review suggest that some types of sleep problems are significantly related to falls in older adults.

The NOS was used to assess the methodological quality of the included studies. The scores for the cross-sectional studies that were included in this review ranged from five to eight while cohort studies ranged from three to seven. Lower scores indicate that there are deficiencies in the methodology of the studies.[93] Most studies included samples that are representative of the population of interest; however, did not provide justification of the sample size. In addition, most studies controlled for basic demographic variables (e.g., age and gender) in addition to comorbidities and number of medications used that are associated with risk of falls. However, the covariates that were adjusted for varied across the studies and the numbers ranged from four to more than ten variables that might result in comparability issues among the studies.

All studies except for one[100] used subjective measures to assess the sleep problems which can result in information bias. Some studies used validated measures to assess sleep problems but most studies did not use a validated tool. These trials reported the questions that were used to identify sleep problems. Additionally, the outcome of falls was primarily collected for the previous 12 months and evaluated by self-report. Since the report of the outcome depended solely on the participants' recall, recall bias is highly possible because of inaccurate memory of the past. It is imperative to accurately define the outcome of interest but there were variations in the definitions of falls across studies that were included.

This systematic review has potential limitations. First, most studies included were cross-sectional in design. Out of the fifteen studies that were included in the review, only five studies were prospective cohort studies. Causal relationship cannot be established in cross-sectional studies. Second, two studies in the review included both institutionalized and non-institutionalized elderly populations and reported the combined or less descriptive results. If the studies had evaluated both populations separately, it would have added to our understanding of the relationship between sleep problems and falls specifically for community-dwelling older adults. Third, there is a measurement bias in evaluating sleep problems and falls. Most studies had their own questionnaires to collect sleep problems that results in heterogeneity in assessments. Lastly, some studies did not provide a definition of sleep problems and falls that were being examined. Consensus in defining the exposure and outcome will facilitate interpretation of the results of future studies.

In the future, there is a need to have more well-designed prospective cohort studies in this population to investigate the relationship between various types of sleep problems and falls. In addition, inclusion of a comparison group without any sleep problems would lead to a stronger conclusion about the association. Sleep problems were measured by self-reports in most of the studies. It has been reported that self-reports of certain aspects of sleep are not significantly different from polysomnographic estimates.[110] However, more studies are needed that measure sleep objectively or at least use validated measurement tools that better assess the exposure and facilitate comparisons among the studies. The same is true for the reporting of falls. There is a need to assess falls by more than one method to confirm each outcome. It may also be helpful to assess the risk more accurately if a detailed evaluation of the falls that participants experience is conducted.

2.3.4 Conclusion:

In conclusion, this review provides insights that sleep problems are an important consideration in older adults with respect to the outcome of falls. Some sleep problems (e.g., problems of nighttime sleep, short or long duration of sleep, and napping) appear to be highly associated with the outcome of falls. Older adults are at risk of falling and many suffer from sleep problems. It is important to consider that sleep problems, rather than medications to aid sleep, could be an important risk factor for falling in older adults. Sleep problems could also add to the risk for falls associated with sedative medications. This review demonstrated that some sleep problems can significantly increase the likelihood of falls in older adults. Future research is needed to establish which specific aspects of sleep problems can cause falls, so that health care professionals can include appropriate assessments and interventions when managing fall risk in patients with sleep problems.

Chapter 3

Objective and Specific Aims

3.1 Hypothesis

Based on the literature review, a hypothesis was formulated. Since most studies did not consider poor sleep as a potential confounder when assessing the association between sleep medication use and falls in older adults, it is of interest to understand whether sleep medications that are used for poor sleep contribute more than poor sleep to the risk of falls. It is reasonable to expect that poor sleep might be a risk factor for falls. Thus, it was hypothesized that there is a relationship between poor sleep, medications to aid sleep, and falls in older adults aged 65 years or older. This hypothesis would be addressed in this research.

3.2 Objective

The objective of this study is to assess the association between the poor sleep, medications prescribed for or used by patients to aid sleep, and a combination of these two factors, on the risk of falls in community-dwelling adults aged 65 years or older.

3.3 Specific Aims

Specific Aims for Project 1: The Association between Sleep Problems, Sleep Medications and Falls in Community-Dwelling Older Adults: Results from the Health and Retirement Study

2010

I. To determine the prevalence of sleep problems, sleep medication use, and falls in community-dwelling older adults

II. To evaluate the association between sleep problems, sleep medication use, and falls in older adults

III. To evaluate the association between sleep problems, sleep medication use, and injurious falls in older adults

IV. To evaluate the association between sleep problems, sleep medication use, and recurrent falls in older adults

Specific Aim for Project 2: The Effect of Sleep Medication Use and Poor Sleep Quality on Risk of Falls in Community-Dwelling Older Adults

To evaluate the association between poor sleep quality, sleep medication use, and falls in community-dwelling older adults

3.4 Significance

Falls are a common and serious problem in older adults. There is a high percentage of older people falling and suffering from the consequences of falls. Sleep problems are also common and detrimental in this population. Poor sleep quality can cause excessive daytime sleepiness, cognitive dysfunction, and decreased psychomotor performance, which all can increase the risk of falls. Moreover, the consumption of medications for sleep is high in this

population, including use of psychotropic agents and sedative hypnotics that are reported to be strong risk factors for falls. Since most studies did not consider poor sleep quality as a potential confounder when assessing the relationship between medications used for sleep and falls in older adults, it is still unclear whether the condition of poor sleep is problematic or the treatments that are used to aid sleep are responsible for the risk of falls. To my knowledge only one study has assessed the association with insomnia, sedative hypnotics, and the combined effect of these two variables on the risk of falls in institutionalized older adults.[40]

This study will help us understand medication-associated risk when treating sleep problems in community-dwelling older adults. This study will enable us to compare those who have poor sleep but are not taking any medications to treat it, those who take medications and have good sleep, and those who take medications but still have poor sleep compared to those with good sleep and no use of sleep medications. This will help us understand whether treating the sleep problems with sleep medications leads to having a lower or higher risk of falls than not treating sleep problems. Overall, the results of this study will assist clinicians in making informed decisions when treating sleep problems in older adults.

Chapter 4

The Association between Sleep Problems, Sleep Medications, and Falls in Community-Dwelling Older Adults: Results from the Health and Retirement Study 2010

In this chapter a study evaluating the association between sleep problems, sleep medications, and falls in community-dwelling older adults using the Health and Retirement Study (HRS) will be discussed. The risk of injurious falls and recurrent falls along with risk of any falls will be investigated. In addition, the prevalence of sleep problems, sleep medication use, and falls in this population will be documented.

4.1 Abstract

Introduction: Studies have shown that the use of psychotropic medications such as sedative hypnotics have a significant association with risk of falls in older adults. However, very few studies have assessed the impact of poor sleep and sleep medication use on the risk of falls among community-dwelling older adults.

Objective: The objectives for this study were: 1) to determine the prevalence of sleep problems, sleep medication use and falls; and 2) to evaluate if sleep problems and sleep medication use was associated with risk of falls, injurious falls, and recurrent falls in community-dwelling adults aged 65 years or older.

Methods: The study population comprised a nationally representative sample of non-institutionalized adults aged 65 years or older participating in the 2010 Health and Retirement Study. The proportion of adults reporting sleep problems, sleep medication use, and fall were

calculated. The effect of combined impact of sleep problems and sleep medications on risk of falls was assessed using logistic regression modeling and controlling for covariates. Statistical analyses were performed using SAS 9.4 statistical software.

Results: Among 9,939 community-dwelling older adults, 36.4% had reported a fall and 40.9% had reported sleep problems in the past two years. Sleep medication use was reported by 21.1% of the adults. Older adults who did not have sleep problems and took sleep medications (OR=1.24; 95% CI= 1.06-1.45) had a significant risk of falls, compared with older adults who did not have sleep problems and did not take sleep medications. Older adults who had sleep problems and did not take sleep medications (OR=1.16; 95% CI= 1.02-1.32) and those who had sleep problems and took sleep medications (OR=1.20; 95% CI= 1.02-1.42) had a significant risk of falls, compared with older adults who did not have sleep problems and did not take sleep medications. All the groups of older adults had an increased risk of injurious falls compared to the reference group. Older adults who had sleep problem and did not take sleep medications (OR=1.27; 95% CI=1.10-1.47) and those who had sleep problems and took sleep medications (OR=1.40; 95% CI= 1.17-1.68) had a significant risk of recurrent falls compared to the reference group.

Conclusion: Sleep problems, sleep medication use, and occurrence of falls are common among community-dwelling older adults. Consistent with previous literature, sleep medication use was associated with risk of falls among these adults. Additionally, those who did not report having sleep problems but who took sleep medications had the highest risk of falls compared with other groups of participants. Further prospective studies are needed to confirm these observed findings in community-dwelling older adults.

4.2 Introduction

One-third of community-dwelling adults aged 65 years and older experience a fall per year.[42] Falls can cause both fatal and nonfatal injuries. Falls are also associated with reduced functioning and earlier admission to nursing homes.[46,47] In 2010, approximately 21,700 of older adults died from unintentional fall injuries.[50] Age, gender, and race are non-modifiable risk factors for falls while modifiable risk factors include acute illness, incontinence, fear of falling, gait and mobility impairment, and visual/sensory deficits.[57,58] Additionally, medications, home hazards, and footwear are other modifiable risk factors for falls in older adults.[58]

One potential risk factor for falls that needs further investigation is self-reported sleep problems.[15] Sleep complaints are common in older adults. Approximately 50% of community-dwelling older adults report poor sleep,[11,12] and studies have shown that sleep problems increase the risk of falls in older adults.[15,94,97,100] Additionally, the consumption of medications to aid sleep (e.g., sedative hypnotics) is common in older adults,[21] and studies have shown such medication use to be associated with risk of falls.[21,62] A meta-analysis found that sedatives and hypnotics (OR=1.47; 95% CI=1.35-1.62), antidepressants (OR=1.68; 95% CI=1.47-1.91), and benzodiazepines (OR=1.57; 95% CI=1.43-1.72) have a significant association with falls in older adults.[62] In another study with community-dwelling older adults, the use of anxiolytics/hypnotics and sedatives significantly increased the risk of falls in men (OR=1.43; 95% CI=1.22-1.67) and in women (OR=1.33; 95% CI=1.22-1.46), when the drug was used up to 85 days before the fall.[111] However, these studies did not consider reported sleep problems as a potential confounder when assessing the relationship.

One study has assessed the association between insomnia and hypnotic use on the risk of falls among institutionalized population.[40] This study found that older adults with insomnia but

who did not take hypnotics, as well as those who have insomnia and who did use hypnotics, had a greater risk of falls compared with those who did not have insomnia and did not use hypnotics.[40] Thus it remains to be seen if such an association exist among community-dwelling older adults. There is clearly a lack of literature on whether the underlying sleep problems cause falls in older adults who take medications for sleep. Therefore, we conducted a study to evaluate the association between sleep problems, sleep medication use, and falls in community-dwelling adults aged 65 years or older. Identifying whether sleep problems, sleep medication use, or both increase the risk of falls may further help healthcare decision makers to better treat older adults with poor sleep and who are already at risk of falling.

Therefore, the objectives were: 1) to determine the prevalence of sleep problems, sleep medication use, and falls; 2) to evaluate if sleep problems and sleep medication use was associated with risk of falls, injurious falls, and recurrent falls in community-dwelling adults aged 65 years or older.

4.3 Methods

4.3.1 Data Source and Study Sample

This study was a cross-sectional analysis of the 2010 Health and Retirement Study (HRS) dataset. HRS is a longitudinal panel study that surveys more than 22,000 Americans every two years and it is conducted by the University of Michigan.[112] The HRS dataset is available for public use with registration. The most recent wave of 2010 data was used in this study. RAND (Research ANd Development) HRS data files were merged with 2010 physical data files for the purpose of the analysis based on the household ID and personal ID.[113]

The HRS included a nationally representative sample of adults aged 50 years and

older. The sample is selected under a multi-stage area probability sample design with oversamples of blacks, hispanics, and residents of Florida. It has six sub-samples who were born in different categories of years.

In this study, we included all community-dwelling adults aged 65 years or older from the HRS dataset. We excluded those respondents who 1) resided in nursing homes during year 2010, 2) did not responded in the year 2010 survey, or 3) had missing values on any of the variables.

4.3.2 Outcome Variables

Falls were assessed in the HRS by asking the question, "Have you fallen down in the last two years?" The response to this question was categorized as "yes" or "no", and was used to define the outcome variable in this study. If the participants responded "yes", they were further asked the number of times they had fallen and whether they had been injured seriously enough to need medical treatment in any of the falls.

4.3.3 Predictor Variables

In the HRS, respondents were asked about their sleep problems through four questions: 1) "How often do you have trouble falling asleep?" 2) "How often do you have trouble with waking up during the night?", 3) "How often do you have trouble with waking up too early and not being able to fall asleep again?", and 4) "How often do you feel really rested when you wake up in the morning?". The responses were categorized as "most of the time", "sometimes", and "rarely or never". For this study, participants were defined as having

a sleep problem, if the respondents answered "most of the time" in any of the first three questions, or "rarely or never" on the fourth question.[15,95] This approach was appropriate since the questions and responses were mostly the same with the past literature.[15,95]

Sleep medication use by respondents was assessed in HRS with the question: "In the past two weeks, have you taken any medications or used other treatments to help you sleep?" The responses were categorized as "yes" or "no", and were used to identify respondents that used sleep medications in this study.

4.3.4 Covariates

Based on previous studies, the covariates that are recognized as a risk factor for falls were included in this study. Demographic variables of interest in this analysis were age, gender, race, education level, and marital status. Other variables of interest included smoking status, alcohol use, health status, number of comorbidities, limitation in ADL, limitation in IADL, limitation in mobility, self-rated eye-sight, and presence of incontinence.[57–59] Age was categorized as "65-74 years old", "75-84 years old", and "85 years or older". Gender was categorized as "male" and "female", race as "Caucasian" and "other", and marital status as "married" and "other". Education level was estimated by the years of education and categorized as "no education", "less than high school", "high school", and "more than high school".

Smoking status was categorized as "current", "former", and "non-smokers". Use of alcohol was classified as "drinker" and "non-drinker". Health status was self-reported and was categorized as "excellent/very good/good", "fair" and "poor". Based on previous studies using HRS data, the number of comorbidities was measured by the sum of the following self-

reported conditions: high blood pressure, diabetes, lung disease, heart disease, stroke, emotional or psychiatric problems, arthritis, and Alzheimer's disease.[114–116] Comorbidities were then categorized as "none", "1-2", "3-4" or "5 or more".

Information about functional status was also taken into account because it is highly related to risk of falls.[58,117] The ADL included bathing, dressing, toileting, eating and transferring. Number of limitations in ADL was the sum of any difficulties on these five tasks. The IADL included ability to use the phone, shopping, preparing food, responsibility for own medications, and ability to handle finances. Number of limitations in IADL was the sum of any difficulties on these five tasks.[115,118] Limitations in mobility included difficulty in any of the following tasks: walking one block, walking several blocks, waking across a room, climbing one flight of stairs, and climbing several flights of stairs activities. Each criteria of functional limitation was categorized as "0", "1-2" or "3-5". Self-rated eye sight was included because impaired vision has been reported to be a risk factor for falls.[58,117] It was categorized as "excellent/very good/good/fair" and "poor/legally blind". The presence of incontinence, categorized as "yes" or "no" was also included.[57]

4.3.5 Statistical Analysis

Using individual sampling weights, weighted descriptive statistics were generated and used to summarize the characteristics of the participants. Percentages were used to describe categorical variables, and mean and standard deviation (SD) were used to describe continuous variables. Chi-square analysis was conducted to determine the association among categorical variables of interest.

The effect of sleep problems, and sleep medication use, and the combined effect on falls were assessed by multiple logistic regression models. Multi-nominal logistic regression

models were used to assess the association between recurrent falls or injurious falls with predictor variables with non-fallers as the reference group. The unadjusted relationship was calculated followed by adjusted relationship with all the covariates in the model. Collinearity was assessed among the predictor variables and covariates in the model. To assess collinearity, correlations among the explanatory variables were assessed. Correlation coefficients larger than 0.9 between the variables mean there is collinearity among the variables. Also, a regression model was performed to use variance inflation factor (VIF) to check for collinearity. A VIF greater than 10 indicates there is collinearity among the variables.

In addition, the effect of each sleep problem ('trouble falling asleep', 'trouble with waking up during the night', 'trouble with waking up too early and not being able to fall asleep again', and 'trouble feeling rested when waking up in the morning') on the risk of falls was assessed. Results were reported as odds ratios (OR) and 95% confidence intervals (CI). A p-value less than 0.05 was considered significant. All statistical analyses were performed using SAS 9.4 statistical software (SAS Institute Inc., Cary, NC, USA).

4.4 Results

4.4.1 Population Characteristics

Based on our inclusion and exclusion criteria, we identified 10,354 older adults from the HRS 2010 dataset. Data from 511 respondents were excluded because of missing data, which was less than 5% of the respondents. Thus, the final dataset consisted of 9,843 participants.

Overall, 35.8% of the older adults reported a fall at least once in the last two years. Among those reporting a fall, 29.9% had serious injuries requiring medical treatment and

60.4% fell more than once. Refer to Figure 4.1. The proportion of older adults reporting sleep problems and sleep medication use was 40.8% and 20.9%, respectively. Among those reported sleep problems, 30.4% of the older adults had used sleep medications. Similarly, among those who did not report having sleep problems, 14.4% of older adults had used sleep medications. Sleep problems were associated with the use of sleep medications ($p<0.0001$) among all participants.

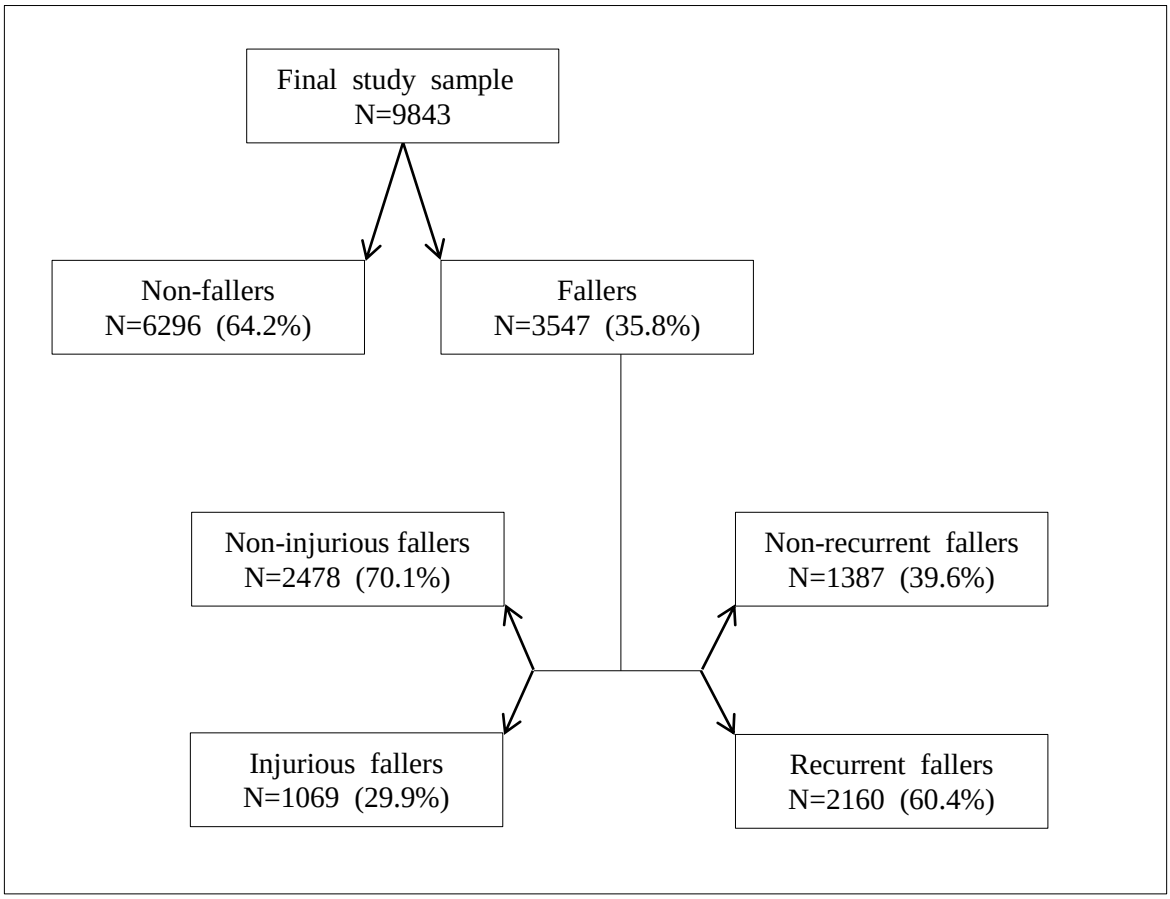

Figure 4.1 Flowchart of the Outcome Variable

Table 4.1 shows the characteristics of the participants by fallers and non-fallers. The proportion of participants with falls was higher among those aged 85 years or older and

among female, compared with non-fallers. Similar results were seen in participants who self-reported their health as bad, had 5 or more comorbidities, had more ADL, IADL, and mobility limitations, and self-reported their eye sight as bad/legally blind. Additionally, the associations between each characteristic and falls were all significant except for smoking status.

Table 4.1 Characteristics of Community-Dwelling Older Adults by Reported Sleep Problems and Sleep Medication Use and Falls in the U.S., 2010

Variable	Total N (%)	Fallers[1]				Non-fallers			
		Sleep problems[2], %		Sleep medication Use[3] , %		Sleep problems, %		Sleep medication Use, %	
		Yes	No	Yes	No	Yes	No	Yes	No
Total	9843	1698	1849	888	2659	2362	3934	1140	5156
Age (years)†									
65-74	5112(55.5)	47.8	51.1	47.5	50.2	55.8	60.7	56.4	59.4
75-84	3505(32.3)	36.5	33.5	36.7	34.3	33.1	29.5	32.5	30.5
>85	1226(12.2)	15.7	15.4	15.8	15.5	11.1	9.8	11.1	10.1
Gender*									
Male	4195(43.7)	38.3	42.7	30.9	43.9	42.9	46.9	35.8	47.6
Female	5648(56.3)	61.7	57.3	69.1	56.1	57.1	53.1	64.2	52.4
Race†									
Caucasian	8207(89.9)	91.8	91.7	94.8	90.8	89.9	88.2	94.1	87.6
Other	1636(10.1)	8.2	8.3	5.2	9.2	10.1	11.8	5.9	12.4
Marital Status†									
Married	5594(54.9)	48.2	51.9	51.1	49.8	54.3	59.5	56.0	57.9
Other	4249(45.1)	51.8	48.1	48.9	50.2	45.7	40.5	44.0	42.1
Education									
No education	66(0.4)	0.5	0.3	0.4	0.4	0.7	0.2	0.2	0.5
< High School	2329(19.9)	24.5	18.4	21.4	21.2	21.6	17.7	16.5	19.8
High School	3448(35.4)	32.6	38.2	34.8	35.8	35.3	35.3	34.0	35.5
> High School	4000(44.3)	42.4	43.1	43.4	42.6	42.5	46.8	49.3	44.2
Smoking									
Current smoker	846(9.4)	9.8	8.2	8.3	9.2	10.4	9.2	8.0	10.1
Former smoker	4769(48.4)	49.9	48.6	50.7	48.7	49.7	46.8	46.8	48.1
Non-smoker	4228(42.2)	40.3	43.2	41.0	42.1	39.9	44.0	45.2	41.8
Alcohol†									
Current drinker	4698(50.8)	45.6	48.5	43.4	48.4	50.3	54.4	53.3	52.8
Non-drinker	5145(49.2)	54.4	51.5	56.6	51.6	49.7	45.6	46.7	47.2
Self-reported Health†	7076(74.5)	54.7	72.9	55.8	67.1	71.4	85.2	74.9	81.3
E/VG/G	2022(18.6)	28.6	20.7	26.8	23.7	21.3	11.9	18.1	14.8
Fair	745(6.9)	16.7	6.4	17.4	9.2	7.3	2.8	7.0	3.9
Bad									
Number of comorbidities†									

0	661(7.6)	2.8	5.4	2.6	4.7	5.9	11.7	4.6	10.7
1-2	4730(49.4)	36.3	47.8	35.2	44.7	48.7	56.1	51.7	53.7
3-4	3753(36.2)	46.5	38.5	47.7	40.5	39.1	29.1	38.8	31.4
5 or more	699(6.8)	14.4	8.3	14.5	10.1	6.3	3.1	4.9	4.2
ADL limitations†									
None	7964(82.4)	64.2	77.5	63.8	73.6	84.0	91.5	87.0	89.1
1-2	1330(12.6)	24.1	16.4	23.9	18.8	11.4	6.6	8.6	8.3
3-5	549(5.0)	11.7	6.1	12.3	7.6	4.6	1.9	4.4	2.6
IADL limitations†									
None	8070(83.4)	69.1	78.7	68.5	76.0	85.3	90.6	84.8	89.5
1-2	1254(12.1)	21.4	15.3	21.8	17.0	11.7	7.0	11.7	8.0
3-5	519(4.5)	9.5	6.0	9.7	7.0	3.0	2.4	3.5	2.5
Mobility limitations†	4137(44.3)	24.7	39.5	26.1	34.6	40.8	56.8	40.7	53.2
None	3485(34.6)	35.2	35.8	34.0	36.0	38.2	31.7	39.9	32.8
1-2	2221(21.1)	40.1	24.7	39.9	29.4	21.0	11.5	19.4	14.0
3-5									
Self-reported eye sight†									
E/VG/G /fair	9161(93.8)	87.6	92.8	88.1	91.1	94.2	96.6	94.6	95.9
Bad/legally blind	682(6.2)	12.4	7.2	11.9	8.9	5.8	3.4	5.4	4.1
Incontinence†									
Yes	2806(28.6)	45.3	30.0	43.1	35.3	31.2	19.4	33.4	21.6
No	7037(71.4)	54.7	70.0	56.9	64.7	68.8	80.6	66.6	78.4

Data source: 2010 HRS (RAND HRS data file and 2010 HRS core physical health file)

*chi-test, p-value<0.05, † <0.0001

1. Fallers=Participants who reported having a fall at least once in the previous two years.

2. Sleep problems=Participants who have trouble "most of the time" in any of sleep problems: 'trouble falling asleep', 'trouble with waking up during the night', 'trouble with waking up too early and not being able to fall asleep again'. Or "rarely or never" on sleep problem: 'trouble feeling rested when waking up in the morning'.

3. Sleep medication Use=Participants who have reported taken any medications or used other treatments to help sleep.

ADL=activities of daily living, IADL=Instrumental Activities of Daily Living, E/VG/G=excellent/very good/good

4.4.2 Associations between Sleep Problems, Sleep Medications, and Falls

Among individuals reporting falls, 43.3% had reported no sleep problems and no use of sleep medications, 31.9% reported sleep problems but no use of sleep medications, 9.6% reported no sleep problems but still used sleep medications, and 15.2% reported sleep problems and used sleep medications.

Table 4.2 Distribution of Predictor Variables against Falls in Community-Dwelling Older Adults in the U.S., 2010

Variables	Fallers N (%)	Non-fallers N (%)
Sleep problems		
Yes	1698 (47.2)	2362 (37.2)
No	1849 (52.8)	3934 (62.8)
Sleep medication use		
Yes	888 (24.8)	1140 (18.8)
No	2659 (75.2)	5156 (81.2)
Sleep problems + Sleep medication use		
No sleep problem + No sleep med use[a]	1515 (43.3)	3443 (54.8)
No sleep problem + Sleep med use[b]	334 (9.6)	491 (8.0)
Sleep problem + No sleep med use[c]	1144 (31.9)	1713 (26.4)
Sleep problem + Sleep med use[d]	554 (15.2)	649 (10.8)

Data source: 2010 HRS dataset (RAND HRS data file and 2010 HRS core physical health file)

*Column percentages are significantly different by Rao-Scott Chi-square test $p<0.05$

a. No sleep problem + No sleep med use= Participants who reported no sleep problems and no use of sleep medications

b. No sleep problem + Sleep med use= Participants who reported no sleep problems but use of sleep medications

c. Sleep problem + No sleep med use= Participants who reported sleep problems and no use of sleep medications

d. Sleep problem + Sleep med use= Participants who reported sleep problems and use of sleep medications

Table 4.3 reports the unadjusted and adjusted associations between sleep problems, sleep medication use, and falls by a logistic model. In the unadjusted model, the risk of falls was significantly higher among individuals with sleep problems, compared with those with no sleep problems. Similarly, the risk of falls was higher among those reporting sleep medication use, compared with those with no sleep medication use. However, the risk was not seen in those using sleep medications after adjusting for covariates.

Compared with participants reporting no sleep problems and no sleep medication use, those reporting sleep problems and sleep medication use had significantly increased risk of falls (OR=1.79; 95% CI=1.54-2.08). However, after adjusting for covariates, older adults with no sleep problems and sleep medication use had the highest increase in the risk of falls

compared with those with sleep problems and no sleep medications use, and to those with sleep problems and sleep medication use. All of the associations were attenuated after adjusting the covariates in the full model but remained significant.

Table 4.3 Association between Sleep Problems, Sleep Medications Use, and Falls in Community-Dwelling Older Adults in the U.S., 2010

Variables	**Unadjusted OR (95% CI)**	**Adjusted OR[e] (95%CI)**
Sleep problems		
Yes	1.51‡ (1.37-1.65)	1.13* (1.01-1.25)
No	Ref	Ref
Sleep medication use		
Yes	1.43‡ (1.26-1.62)	1.14 (1.00-1.31)
No	Ref	Ref
Sleep problems + Sleep medication use		
No sleep problem + No sleep med use[a]	Ref	Ref
No sleep problem + Sleep med use[b]	1.52‡ (1.31-1.78)	1.24† (1.05-1.47)
Sleep problem + No sleep med use[c]	1.53‡ (1.36-1.73)	1.16* (1.02-1.32)
Sleep problem + Sleep med use[d]	1.79‡ (1.54-2.08)	1.19* (1.01-1.41)

Data source: 2010 HRS dataset (RAND HRS data file and 2010 HRS core physical health file)

*<0.05, † <0.01, ‡ <0.0001

Ref=reference

a. No sleep problem + No sleep med use= Participants who reported no sleep problems and no use of sleep medications

b. No sleep problem + Sleep med use= Participants who reported no sleep problems but use of sleep medications

c. Sleep problem + No sleep med use= Participants who reported sleep problems and no use of sleep medications

d. Sleep problem + Sleep med use= Participants who reported sleep problems and use of sleep medications

e. Full model: Adjusted for age, gender, education, marital status, race, self-reported health, alcohol, number of comorbidities, limitations in IADL, limitations in ADL, limitations in mobility, self-rated eye sight and incontinence

4.4.3 Associations between Sleep Problems, Sleep Medications, and Injurious Falls

The fallers were further categorized into injurious fallers and non-injurious fallers. Among the total sample, 10.7% experienced an injurious fall while 25.1% experienced a non-injurious fall. The proportion of those with sleep problems was greater in injurious fallers

than non-injurious fallers and non-fallers. Similarly, the proportion of those using sleep medications was greater in injurious fallers than non-injurious fallers and non-fallers.

Table 4.4 Distribution of Predictor Variables against Injurious Falls in Community-Dwelling Older Adults in the U.S., 2010

Variables	Non-fallers N (%)	Non-injurious fallers N (%)	Injurious fallers N (%)
Sleep problems			
Yes	2362 (37.2) ‡	1178 (46.4) †	520 (49.0)
No	3934 (62.8)	1300 (53.6)	549 (51.0)
Sleep medication use			
Yes	1140 (18.8) ‡	579 (22.6) ‡	309 (30.0) ‡
No	5156 (81.2)	1899 (77.4)	760 (70.0)
Sleep problems+ Sleep medication use			
No sleep problem + No sleep med use[1]	3443 (54.8) ‡	1088 (45.3) ‡	427 (38.5) ‡
No sleep problem + Sleep med use[2]	491 (8.0)	212 (8.3)	122 (12.6)
Sleep problem + No sleep med use[3]	1713 (26.4)	811 (32.1)	333 (31.6)
Sleep problem + Sleep med use[4]	649 (10.8)	367 (14.3)	187 (17.4)

Rao-Scott Chi-square test for column percentages p-value *<0.05, † <0.01, ‡ <0.0001

a. No sleep problem + No sleep med use= Participants who reported no sleep problems and no use of sleep medications

b. No sleep problem + Sleep med use= Participants who reported no sleep problems but use of sleep medications

c. Sleep problem + No sleep med use= Participants who reported sleep problems and no use of sleep medications

d. Sleep problem + Sleep med use= Participants who reported sleep problems and use of sleep medications

Multi-nominal logistic model was preformed to assess the effect of sleep problems and sleep medication use on the risk of injurious falls. Non-fallers were considered as the reference group. Compared with non-users, sleep medication users had a 40% higher risk of having an injurious fall. All the groups were more likely to experience injurious falls compared with the group with no sleep problems and no use of sleep medications. However, the effect of sleep problems and sleep medication use did not increase the risk of non-injurious falls.

Table 4.5 Association between Sleep Problems, Sleep Medications Use, and Injurious Falls in Community-Dwelling Older Adults in the U.S., 2010

Variables	Non-injurious fallers Adjusted OR (95% CI)	Injurious fallers Adjusted OR[e] (95% CI)
Sleep problems		
Yes	1.12 (1.00-1.25)	1.16 (0.98-1.36)
No	Ref	Ref
Sleep medication use		
Yes	1.04 (0.89-1.22)	1.40† (1.15-1.71)
No	Ref	Ref
Sleep problems + Sleep medication use		
No sleep problem + No sleep med use[a]	Ref	Ref
No sleep problem + Sleep med use[b]	1.05 (0.86-1.30)	1.76‡ (1.40-2.20)
Sleep problem + No sleep med use[c]	1.13 (0.99-1.29)	1.25* (1.02-1.54)
Sleep problem + Sleep med use[d]	1.12 (0.92-1.35)	1.40* (1.08-1.82)

Data source: 2010 HRS dataset (RAND HRS data file and 2010 HRS core physical health file)

*<0.05, † <0.01, ‡ <0.0001

Ref=reference

a. No sleep problem + No sleep med use= Participants who reported no sleep problems and no use of sleep medications

b. No sleep problem + Sleep med use= Participants who reported no sleep problems but use of sleep medications

c. Sleep problem + No sleep med use= Participants who reported sleep problems and no use of sleep medications

d. Sleep problem + Sleep med use= Participants who reported sleep problems and use of sleep medications

e. Full model: Adjusted for age, gender, education, marital status, race, self-reported health, alcohol, number of comorbidities, limitations in IADL, limitations in ADL, limitations in mobility, self-rated eye sight and incontinence

4.4.4 Associations between Sleep Problems, Sleep Medications, and Recurrent Falls

Recurrent falls were defined as falling more than once in the past two years. Among the total sample, 14.2% were single fallers, and 21.7% were recurrent fallers. Participants using medications or treatments for sleep were approximately 19% among non-fallers, 22% among single fallers, and 27% in recurrent fallers. Recurrent fallers had higher proportion of those with sleep problems compared with single fallers and non-fallers. After combining sleep problems and sleep medication use, recurrent fallers had a higher proportion of those

with both sleep problems and sleep medication use compared with single fallers and non-fallers.

Table 4.6 Distribution of Predictor Variables against Recurrent Falls in Community-Dwelling Older Adults in the U.S., 2010

Variables	Non-fallers N (%)	Single fallers N (%)	Recurrent fallers N (%)
Sleep problems			
Yes	2362 (37.2) ‡	569 (40.2) ‡	1129 (51.8)
No	3934 (62.8)	818 (59.8)	1031 (48.2)
Sleep medication use			
Yes	1140 (18.8) ‡	305 (21.6) ‡	583 (26.9) ‡
No	5156 (81.2)	1082 (78.4)	1577 (73.1)
Sleep problems + Sleep medication use			
No sleep problem + No sleep med use[1]	3443 (54.8) ‡	679 (49.7) ‡	836 (39.0) ‡
No sleep problem + Sleep med use[2]	491 (8.0)	139 (10.1)	195 (9.2)
Sleep problem + No sleep med use[3]	1713 (26.4)	403 (28.7)	741 (34.1)
Sleep problem + Sleep med use[4]	649 (10.8)	166 (11.5)	388 (17.7)

Rao-Scott Chi-square test for column percentages p-value *<0.05, † <0.01, ‡ <0.0001

a. No sleep problem + No sleep med use= Participants who reported no sleep problems and no use of sleep medications

b. No sleep problem + Sleep med use= Participants who reported no sleep problems but use of sleep medications

c. Sleep problem + No sleep med use= Participants who reported sleep problems and no use of sleep medications

d. Sleep problem + Sleep med use= Participants who reported sleep problems and use of sleep medications

Multi-nominal logistic model was performed to assess the effect of sleep problems and sleep medication use on the risk of recurrent falls. Non-fallers were considered as the reference group. Compared with participants with no sleep problems, those with sleep problems were 26% more likely to have a recurrent fall. Similarly, compared with non-users of sleep medications, users had 21% higher odds of having a recurrent fall. However, sleep problems and sleep medication use did not affect the risk of non-recurrent falls. In addition, the group with sleep problems and sleep medication use had a significantly higher risk of

recurrent falls compared with the group with no sleep problems and no sleep medication use.

Table 4.7 Association between Sleep Problems, Sleep Medications Use, and Recurrent Falls in Community-Dwelling Older Adults in the U.S., 2010

Variables	Single falls Adjusted OR (95% CI)	Recurrent falls Adjusted OR[e] (95%CI)
Sleep problems		
Yes	0.97 (0.83-1.12)	1.26† (1.12-1.42)
No	Ref	Ref
Sleep medication use		
Yes	1.05 (0.89-1.23)	1.21* (1.04-1.42)
No	Ref	Ref
Sleep problems + Sleep medication use		
No sleep problem + No sleep med use[a]	Ref	Ref
No sleep problem + Sleep med use[b]	1.24 (0.99-1.55)	1.25 (1.00-1.58)
Sleep problem + No sleep med use[c]	1.03 (0.86-1.23)	1.27† (1.10-1.47)
Sleep problem + Sleep med use[d]	0.93 (0.75-1.16)	1.40† (1.17-1.68)

Data source: 2010 HRS dataset (RAND HRS data file and 2010 HRS core physical health file)

*<0.05, † <0.01, ‡ <0.0001

Ref=reference

a. No sleep problem + No sleep med use= Participants who reported no sleep problems and no use of sleep medications

b. No sleep problem + Sleep med use= Participants who reported no sleep problems but use of sleep medications

c. Sleep problem + No sleep med use= Participants who reported sleep problems and no use of sleep medications

d. Sleep problem + Sleep med use= Participants who reported sleep problems and use of sleep medications

e. Full model: Adjusted for age, gender, education, marital status, race, self-reported health, alcohol, number of comorbidities, limitations in IADL, limitations in ADL, limitations in mobility, self-rated eye sight and incontinence

4.4.5 Association between Type of Reported Sleep Problems and Falls

Among those individuals reporting a fall, 16.9% reported having trouble falling asleep, 31.1% reported trouble waking up during the night, 15.6% reported trouble with waking up too early and not being able to fall asleep again, and 14.8% reported trouble feeling rested when waking up in the morning.

Table 4.8 reports the relationship between type of sleep problem and the risk for falls. The risk of falls was higher among respondents reporting any of the four sleep problems in the unadjusted associations. However, after adjusting for covariates including the sleep medications use, only respondents with "trouble falling asleep" had an increased risk of falls.

Table 4.8 Association between Type of Sleep Problems and Falls in Community-Dwelling Older Adults in the U.S., 2010

Variables	Unadjusted OR (95% CI)	Adjusted OR[a] (95% CI)
Trouble falling asleep		
Yes	1.75‡ (1.54-1.98)	1.22† (1.07-1.40)
No	Ref	Ref
Trouble with waking up during the night		
Yes	1.35‡ (1.22-1.50)	1.07 (0.96-1.20)
No	Ref	Ref
Trouble with waking up too early and not being able to fall asleep again		
Yes	1.50‡ (1.31-1.71)	1.12 (0.98-1.30)
No	Ref	Ref
Trouble feeling rested when waking up in the morning		
Yes	1.54‡ (1.34-1.78)	0.98 (0.84-1.14)
No	Ref	Ref

Data source: 2010 HRS dataset (RAND HRS data file and 2010 HRS core physical health file)

*<0.05, † <0.01, ‡ <0.0001

Ref=reference

a. Full model: Adjusted for age, gender, education, marital status, race, self-reported health, alcohol, number of comorbidities, limitations in IADL, limitations in ADL, limitations in mobility, self-rated eye sight, incontinence and sleep medication use

4.5 Discussion

The purposes of this study were to determine the prevalence of sleep problems, sleep medication use, and falls, and to assess the effect of sleep problems, sleep medication use, and the combined effect on the risk of falls, injurious falls, and recurrent falls in community-dwelling older adults.

In a representative sample of community-dwelling older adults in 2010, this study

showed that 35.8% of the participants had a fall at least once in the last two years. Similar percentage of older adults had fallen compared with previous studies reporting that one in three community-dwelling older adults have a fall per year.[119] However, there was no standardized definition of fall in the HRS survey. The question regarding falls in the HRS survey only asked whether the participants have fallen down in the last two years, but what constitutes a fall was not defined further. About 5 to 10% of falls in community-dwelling older adults results in severe head injury and joint dislocation, and an additional 5% in a fracture.[120] Approximately 30% of falls led to serious injuries in this study, thus, it is possible that respondents were more likely to remember to report falls that required medical treatments. Additionally, this study found that 40.8% had sleep problems in the last two years. The prevalence was similar to previous studies.[11,12] Only 20.9% used medications or other treatments to help sleep in the past two weeks, and among those who had sleep problems, only 30.4% used sleep medications. This could mainly be because the use of sleep medications was assessed in the past two weeks in the survey which was a short time frame relative to the time over which sleep problems were reported.

Older adults with reported sleep problems had a significant increase in the risk of falls after adjusting for covariates (OR=1.13; 95% CI=1.01-1.25). The possible mechanisms could be that poor sleep may cause daytime sleepiness, cognitive dysfunction, and slower response time that could result in falls.[42,44,45,117] Although the risk attenuated after considering covariates, the risk was still observed. However, older adults who used sleep medications or other treatment for sleep did not find risk of falls after adjusting for covariates. A study by Ensrud and colleagues that followed community-dwelling older women on hypnotics for 1 year for incidence of falls found that women taking benzodiazepines (multivariate odds ratio, MOR=1.34; 95% CI=1.09-1.63), antidepressants (MOR=1.54; 95% CI=1.14-2.07), or

antiepileptics (MOR=2.56; 95% CI=1.49-4.41) were likely to experience falls at least once.[69] Sedative hypnotics could increase falls by the effect on postural instability, psychomotor impairment and cognitive dysfunction.[67] Furthermore, the risk of falls associated with these medications could be increased because of age-related changes in physiology resulting in altered pharmacokinetics and pharmacodynamics in older adults.[67] Therefore, the lack of significance in the finding could again be because of a short time frame on question asking about sleep medication use.

In addition, there was increased risk of falls among older adults who had sleep problems and who used sleep medications. However, after adjusting for covariates, older adults with no sleep problems and who used sleep medications had the highest risk of falls compared with other groups. This finding suggests that sleep medications did not have a protective effect on falls when considering sleep problems in the association. A study by Avidan and colleagues assessed the risk of falls in the same four groups with a cross-tabulation of insomnia and use of sedative hypnotics: 1) insomnia, hypnotic use, 2) insomnia, no hypnotic use, 3) no insomnia, hypnotic use, and 4) no insomnia, no hypnotic use.[40] However, the results are inconsistent with the current study. Avidan and colleagues found that insomniacs who did not take hypnotics (OR=1.55; 95% CI =1.41-1.71) and insomniacs who took hypnotics had a significant increase in the risk of falls (OR=1.32; 95% CI=1.02-1.70).[40] Insomnia without hypnotics had the highest risk of falls compared with any other groups and hypnotic use had a protective effect on falls in older adults, suggesting that the condition of insomnia might have been better treated with the medication resulting in fewer falls.[40] Although the study by Avidan and colleagues and the current study have conflicting results, the presence of sleep problems, such as insomnia, was found as a key risk factor for falls.

The risk of injurious falls associated with sleep problems and sleep medication use

was also assessed. Sleep medication use but not sleep problems was significantly associated with a risk of injurious falls. A prospective cohort study also found a significant increased risk of injurious falls related to the use of sedative or hypnotics (RR=1.50; 95% CI=1.03-2.19),[88] but other studies did not find sleep problems to be related to falls that required medical attention for an injury.[96,103] The effect of sleep problems and sleep medication use on the risk of injurious falls showed that the group with no sleep problems and sleep medication use had the highest risk of injurious falls than those with sleep problems and no sleep medications use, and to those with sleep problems and sleep medication use compared to the reference group. This pattern was similar to the risk of falls generally.

Moreover, the risk of recurrent falls was studied. Older adults with sleep problems and those with sleep medication use were more likely to have a recurrent fall. Other studies also showed the association between sleep problems and recurrent falls,[104] and use of CNS medications and recurrent falls.[121] The risk of recurrent falls was seen in older adults with sleep problems and no sleep medication use and in those with sleep problems and sleep medication use. The effect of sleep problems and sleep medication use was not significant for risk of a single fall.

In this study, the risk of falls by type of reported sleep problem among older adults was also assessed. Each sleep problem had a significant increase in the unadjusted risk of falls, however, only 'trouble falling asleep' significantly increased the risk of falls after adjusting for covariates including the use of sleep medications. A study by Brassington and colleagues evaluated the same aspects of sleep disturbance in older adults as in the current study except for one type of sleep problem, which was 'trouble feeling rested when waking up in the morning'.[15] The authors found that difficulty falling asleep at night (OR=1.53; 95% CI=1.04-2.24), waking up during the night (OR=1.91; 95% CI=1.44-2.54), and waking up too

early in the morning and not being able to fall asleep again (OR=1.64; 95% CI=1.11-2.42) were significantly associated with the occurrence of falls after adjusting for covariates including a use of prescription medication.[15] The number of covariates that were adjusted for was fewer than in the current study, and therefore may not have adjusted for the effect of confounders such as limitations in ADL, instrumental IADL, mobility, and incontinence. In contrast, Teo and colleagues evaluated the same categories of nighttime sleep problems and used the same scale as Brassington and colleagues and reported conflicting findings.[95] Teo and collegues did not find a significant increase in the risk of falls in the same nighttime sleep problems after adjusting for the covariates age, CNS drug use, cardiovascular system drug use, and the presence of nocturia.[95] While results from our study add to the findings from previous studies, further prospective research in community-dwelling older adults is needed to accurately quantify the risk of falls by type of sleep problem.

Some strengths of this study may be noted. Since the HRS study had a representative sample of older adults, national estimates were obtained. Also, several risk factors, such as limitations in ADL and IADL, were controlled as covariates in this study. However, as with any study, this study has limitations. First, since information was self-reported, there could be misclassification bias or recall bias. Second, because this is a cross-sectional study based on self-reported information, causal relationships could not be explored. Third, falls were not clearly defined in the HRS survey. The study would have been strengthened if the survey had included a standard definition of falls. Variations in the definition of falls could result in misclassification bias. Fourth, respondents were asked if they had experienced a fall and sleep problems in the last two years. This may have resulted in recall bias, thus limiting the generalizability of our findings. Additionally, unlike other survey questions where respondents were asked to provide information based on their experience during the last two

years, the survey question on assessing sleep medication use only asked respondents to provide information based on their experience during the past two weeks. The differences in the time interval may result in lack of temporal relationship between drug exposure and the outcome. Still, the study results add valuable information to the current literature by shedding light on sleep problem, sleep medication use, and falls in community-dwelling older adults. Finally, information on the circumstances of falls were not collected in HRS and were therefore not included in this study. This information would have been useful and should be collected in future studies.

4.6 Conclusion

In conclusion, this study found that sleep problems, use of sleep medications, and falls are common among community-dwelling older adults. This study adds to the literature by assessing the combined effect of sleep problems and sleep medication use on risk of falls, injurious falls, and recurrent falls in community-dwelling older adults. Older adults without sleep problems and taking sleep medication had the highest risk of falls compared to those with sleep problems and taking sleep medications, those with sleep problems and not taking sleep medications, and those without sleep problems and not taking sleep medications. Health care professionals should consider medication-associated risk when treating sleep problems in community-dwelling older adults. More studies are needed to examine this association in community-dwelling older adults.

Chapter 5

The Effect of Sleep Medication Use and Poor Sleep Quality on Risk of Falls in Community-Dwelling Older Adults

This chapter described a community engage research study where primary data was collected to investigate the effect of poor sleep quality and sleep medication use on risk of falls in community-dwelling older adults is described.

5.1 Abstract

Introduction: Sleep complaints and the consumption of medications to aid sleep are common in older adults. However, very few studies have assessed the combined impact of poor sleep and sleep medication use on the risk of falls.

Objective: The main objective was to evaluate the association between sleep medication use, sleep quality, and falls in independently-living adults 65 years or older. Sleep quality, use of sleep medications, and the outcome "falls" in the population were also described.

Methods: This was a 6-month prospective cohort study of older adults residing in independent living senior housing. Sleep quality was assessed with the Pittsburgh Sleep Quality Index (PSQI) and a medication review was conducted. Falls were collected over 6 months by diary. Logistic regression modeling was used to examine the effect of sleep problems, sleep medications, and both on the risk of falls after controlling for covariates. Statistical analysis was performed using SAS 9.4 statistical software.

Results: Among 113 community-dwelling older adults (female=76.1%, mean age ±SD= 81.1

±8.6), 46.9% fell at least once during 6 months. Of the total participants, 62.8% of those had poor sleep quality based on the mean PSQI score of more than five. Among sleep medication users, 22% used multiple sleep aids, and 40% used potentially inappropriate Over-the-Counter (OTC) products and alcohol for sleep. Sleep medication use (OR=2.65; 95% CI=1.04-6.72), but not poor sleep quality, predicted prospective falls after adjusting for covariates. Compared with participants reporting good sleep quality and no sleep medication use, those who report poor sleep quality and sleep medication use had an increased risk of falls after adjusting for covariates (OR=3.23; 95% CI=1.05-9.91). The risk for falls was not significant in group with good sleep quality and sleep medication use and the group with poor sleep quality and no sleep medication.

Conclusion: This study was the first to evaluate the associations between poor sleep quality, use of sleep medications, and falls in community-dwelling older adults. A combined effect of sleep quality and sleep medication use on the risk of falls suggests that medication effectiveness may be an important factor to consider in understanding the risk of falls associated with sedative medications.

5.2 Introduction

Falls are among the most common and serious problems faced by older adults. One third of adults who are 65 years of age or more fall at least once in the community, and the percentage increases up to 50% among those aged 80 years old or more.[45] Risk factors for falls can be classified as modifiable and non-modifiable factors. Modifiable risk factors include impaired vision, impaired balance and mobility, orthostatic hypotension, fear of falling, mood disorder, osteoporosis, incontinence, and polypharmacy while non-modifiable risk factors include age, gender, and race.[57,58]

Several studies have documented the risk of falls associated with sedative hypnotics. A meta-analysis which evaluated the impact of nine medication classes on falls in older adults found that sedatives and hypnotics (OR=1.47; 95% CI=1.35-1.62), antidepressants (OR=1.68; 95% CI=1.47-1.91), and benzodiazepines (OR=1.57; 95% CI=1.43-1.72) have a significant association with falls.[62] Another meta-analysis which provided an update of the literature in 2011 found the psychotropic drugs such as antidepressants (OR=1.44; 95% CI=1.31-1.59), benzodiazepines (OR=1.31; 95% CI=1.16-1.47), and hypnotics (OR=1.40; 95% CI=1.24-1.58) were significantly related to any falls in adults who are aged more than 60 years.[63] This suggests that medications that are frequently used to aid sleep have an association with falls in older adults. Sedative hypnotics may cause daytime sedation and dizziness, and cause problems associated with reaction time and coordination that can increase the risk of falls in this population.[64–67] Most studies that have assessed the relationship between sedative hypnotics did not investigate whether sleep problems could be the underlying risk factor for falls.

Sleep complaints are common in older adults.[11,12] Approximately 50% of independently living older adults aged 65 years or older in U.S. reporting a sleep complaint.[11]

Older adults are often dissatisfied with the quality of their sleep.[13] Poor sleep quality is related to decreased psychomotor performance[18] and cognitive function that may increase the risk of falls.[40] Few studies have shown an increased risk of falls in older adults with poor sleep (e.g., nighttime sleep problems, daytime sleepiness and short or long sleep duration).[15,94,95,101,102]

A study that evaluated the relationship between insomnia, hypnotic use, and falls among institutionalized older adults found that older adults with insomnia with no hypnotic use and those with insomnia with hypnotic use had increased risks of falls compared with those without insomnia and without hypnotic use. However, it remains unclear whether the drug or the indication for the drug use, which is poor sleep, contribute more to the risk of falls in community-dwelling older adults. There is a need to assess confounding by indication between poor sleep quality, sleep medication use, and falls. Therefore, the objective of this study was to determine if sleep medication use and poor sleep quality is associated with risk of falls in community-dwelling adults aged 65 years or older.

5.3 Methods

5.3.1 Study Setting

This study was conducted in three senior housing settings located in Richmond, Virginia. Residents of the largest of these three communities completed a survey conducted by a retirement community indicating that falls, sleep problems and overmedication were all among their top ten health concerns (data not published). This study was responsive to their interest in addressing these issues through research. The study protocol, consent forms and

recruitment materials for the study were approved by the Virginia Commonwealth University Institutional Review Board (IRB) in March 2013. (Appendices B, C, and D)

5.3.2 Study Design and Study Participants

This was a multi-center, prospective cohort study with a follow-up of 6 months to observe the incidence of falls. The study enrolled independently living adults aged 65 years or older. The first volunteer was enrolled in June 2013 and the recruitment was conducted through February 2014. The study was completed in August 2014.

Individuals were included if they met the following criteria:

(1) Persons who were aged 65 years or above.

(2) Persons who were able to read and converse in English.

(3) Persons who were expected to reside at the retirement community for at least 6 months after the study initiation. Volunteers were asked if they had any plans to move out of the retirement community within 6 months.

Individuals were excluded if they met the following criteria:

(1) Persons unable to provide written informed consent. Participation in the study was voluntary. There was no penalty or loss of benefits for not participating.

(2) Persons who were found to be taking any medications for cognitive impairments (i.e., donepezil, rivastigmine, galantamine, or memantine) in the medication review. Those who had problems with cognitive function may have problems remembering their falls during the study follow-up period.

(3) Persons who scored 23 or below on the Mini Mental State Examination (MMSE) were excluded. Questions on the MMSE were asked by the researcher. MMSE is commonly used to evaluate cognitive status in older adults. It tests components of orientation, registration, attention and calculation, recall, language, and visuospatial construction. The total score ranges from 0 to 30 and a score of 23 or below may indicate the presence of cognitive impairment. It takes about 15 minutes to complete.[64] Those who had problems in cognitive function may have problems remembering their falls during the study follow-up period.

(4) Persons who were not willing to keep the monthly log. The fall diaries were used to document falls. Those who did not wish to keep the fall diaries could not be followed during the study period.

(5) Persons who were nonambulatory. Those who were bed bound or used wheelchairs exclusively for ambulation were excluded because their risk of falls may be very different from those who are ambulatory.

5.3.3 Study Recruitment

Several methods were used to recruit participants in this study.

(1) The researcher attended short meetings in the senior housing communities to briefly introduce the study. Short meetings were either at a town hall meeting or morning coffee breaks.

(2) A brief description of the study was introduced in the weekly newsletter in the communities.

(3) Advertising flyers approved by the Virginia Commonwealth University IRB were posted in the pharmacy or common area in the communities.

(4) A poster session about sleep problems in older adults that could be beneficial to the residents was held in the senior housing communities. Advertisement flyers and study brochures were placed near the poster so that the residents had a chance to be introduced to the study. Also, those who were interested in the study were screened for study eligibility according to the inclusion and exclusion criteria.

(5) The IRB approved consent form was given to eligible participants who volunteered. They had time to review the consent form with their family or primary care physician before making a final decision.

(6) After the informed consent, name and contact information were collected from the participants. Telephone contacts with these volunteers were conducted by the researcher to arrange a meeting at a private area within the community or at the participant's residence based on his/her preference.

(7) Compensation was provided with a gift card or cash of $10 at the beginning of the study and $25 at the end of the study.

The recruitment period was from June 2014 to February 2014 and advertising continued throughout this period.

5.3.4 Data Collection

Baseline assessment:

Baseline demographic information was collected including age, gender, race, education level and smoking status (Appendix E: Baseline Demographics).

There were two predictor variables: the quality of sleep and the use of medications for sleep. Upon enrollment, the PSQI was administered to measure the quality of sleep. Poor sleep quality was defined as a total score of more than five on the PSQI.[14] Volunteers were identified as having either poor quality of sleep or not.

The PSQI is a validated measure of subjective sleep quality and sleep disturbances over a 1-month period.[14] It has 19 items and is divided into sections that measure subjective sleep quality, sleep latency, sleep duration, sleep efficiency, sleep disturbances, use of sleeping medication, and daytime dysfunction. The scores range from 0 to 21 (0= best sleep quality and 21= poorest sleep quality). A score of more than five was used to identify those with poor sleep quality. The researcher guided participants through the survey. Approximately 15 minutes was needed to complete the survey. This instrument was selected because of its' robust psychometric properties related to general sleep quality and applicability.[122]

The other predictor variable was the use of medications for sleep. A medication review was conducted to identify the use of medications for sleep. Medications that were prescribed for, or used by, patients to aid sleep, including alcohol (Appendix F: Medication Review, Appendix G: Questions about Alcohol Intake for Sleep) were identified during the medication review at the baseline assessment. Participants were asked to bring all their medications, including prescription medications, nonprescription medications, herbal aids and dietary supplements that they have used within the past month at the time of the interview. If they did not bring their medications, medical prescriptions or drug packages were accepted. All drugs were recorded with generic names. For complete data collection, the

dose, and the frequency of medication use were recorded. Participants were categorized as sleep medication users if they verbally disclosed that using any agents for sleep during the previous month at the baseline assessment, and as non-users if they verbally stated that they did not use any agents for sleep in the previous month at the baseline assessment.

Several covariates were measured at the baseline assessment. Falls Risk for Older People in the Community scale (FROP-Com) was used to measure the baseline risk of falls.[123] The FROP-Com was selected for this study because it is a comprehensive falls assessment that asks about multiple factors related to risk of falls in community-dwelling older adults. It is a multidimensional assessment that asks questions about a history of falls in the past 12 months, number of medications, and cognitive, marital and functional status. This questionnaire also assesses the number of medical conditions, number of prescription medications, and number of specific types of medications (i.e., sedatives, antidepressants, anti-epileptics, central acting analgesics, digoxin, diuretics, type 1a antiarrythmics, and vestibular suppressants). The answers on questions about medications in FROP-Com were obtained from the medication reviews and the answers about medical conditions were obtained from the Functional Comorbidity Index (FCI) answers. Moreover, the FROP-Com assesses sensory loss including feet and footwear problems, continence, nutrition, environment, balance, and gait/physical activity. It is a 28-item clinician-rated scale of 13 risk factors for falling. Each item is scored either dichotomously or on a 0 to 3 scale. The overall score is from 0 to 60, with a score of 0 to 11 indicating mild fall risk, 12 to 18 indicating a moderate fall risk, and 19 to 60 indicating a high fall risk. It is a reliable tool and has been validated in older adults. It requires no equipment or specialist knowledge and it will take about 15 to 20 minutes to complete.

The Functional Comorbidity Index (FCI) was used to measure comorbidities,[124] however, it was only used in the analysis to provide the answers for FROP-Com about medical conditions. It was developed specifically for use in the general population with physical function as the outcome of interest. The FCI can be used to adjust for the effect of comorbidity on physical function in the same manner that other comorbidity indices are used to adjust for the effect of comorbidity on mortality. It contains diseases (e.g., visual impairment, osteoporosis, arthritis etc.) for a total of 18 diagnoses scored by adding the number of "yes" answers. A score of 0 indicates no comorbid illness and a score of 18 indicates the highest number of comorbid illnesses. About 5 minutes was needed for completion (Appendix H: Functional Comorbidity Index).

Table 5.1 Predictor Variables and Covariates Measured during the Baseline Assessment

Variables	**Measurement**
Predictor variables	
Sleep quality	PSQI
Sleep medication use	Medication Reviews (Appendix F)
Covariates	
Age[58,125]	Baseline Demographics (Appendix E)
Gender[58,126]	
Race[58,127]	
Education level[58,128]	
Smoking status[101–103]	
Marital status	FROP-Com
Baseline risk of falls	

Questionnaires were administered on one occasion (one point in time). The estimated time to complete the baseline assessment was one hour. The researcher or a research assistant administered the surveys to the participants. The baseline assessment was conducted with each participant either in a private area within the housing community or in their apartment, according to the participant's preference.

Follow-up assessment:

The outcome of interest was the incidence of falls. The definition of falls provided by the WHO which is "an event which results in a person coming to rest inadvertently on the ground floor or other lower level"[54] was used. All occurrences of falls were collected over a 6-month period. The researcher demonstrated to the participants what a fall is to capture falls according to the definition provided by the WHO. This was necessary because individuals may have different ideas about what qualifies as a fall.

During the follow-up period of 6 months, the investigator contacted participants on a monthly basis either by meeting with them in person or calling them on the phone. Participants were asked if they had experienced any falls in the past month and if they had made any change in the usage of medications for sleep (e.g., whether they started taking any new medications for sleep, stopped taking medications for sleep, or switched to different medications for sleep) (Appendix I: Monthly Follow-up Questions). This information was used to assess whether there was change from baseline assessment of sleep medication use. Several questions from the PSQI about sleep duration and subjective sleep quality were asked to calculate sleep efficiency and determine whether there was a change in sleep efficiency over the 6 month follow up period.

In addition, participants were given fall diaries (Appendix J: The Fall Diary). Participants were asked to put a check mark at the end of each week, if they experienced no falls during the previous seven days. They were also asked to call the researcher within 48 hours, if a fall has occurred. Questions (Appendix K: Fall Questionnaire) were asked by the researcher to ascertain that a fall had occurred (according to the fall definition) when the participants called to report a fall. The first four questions in the "Fall Questionnaire" helped identify and ascertain falls in older adults, the fifth question was used to obtain descriptive

information on the outcome, and the last question was used to observe whether participants had changed any of the medications after the recent fall. During the monthly meetings, fall diaries were reviewed by the researcher. The researcher encouraged those who are not completing their diaries and re-educated them about falls to reinforce the definition of falls at the monthly meetings.

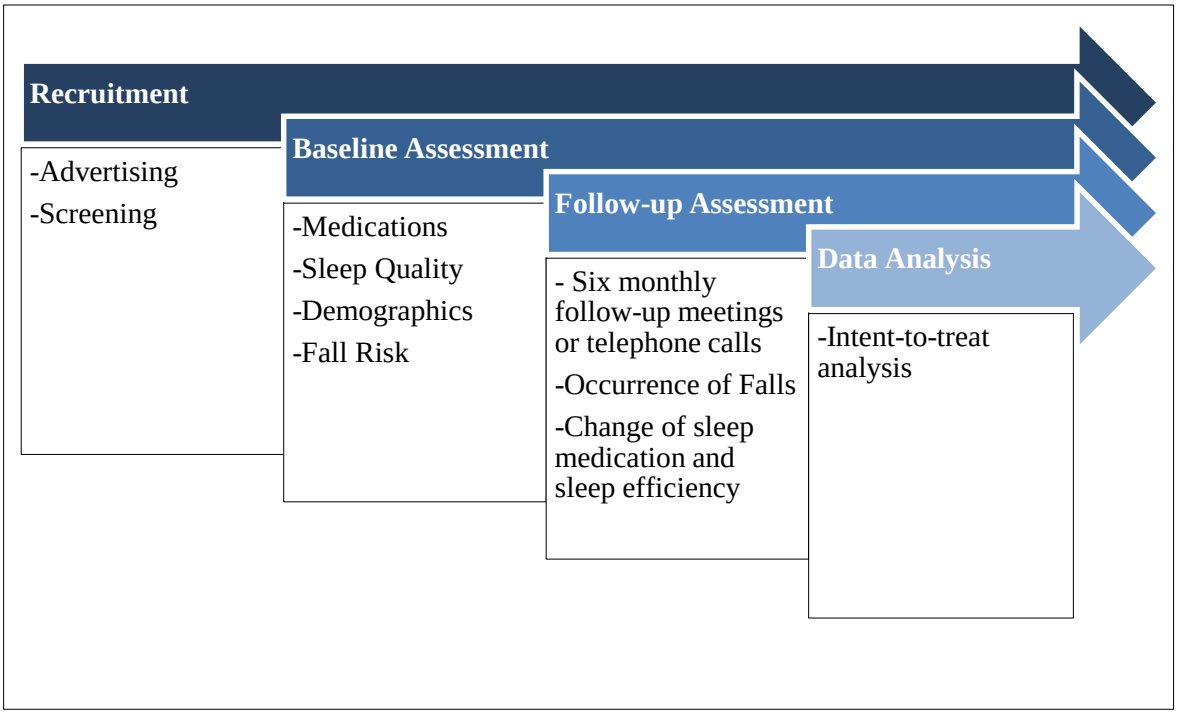

Figure 5.1 Summary of Data Collection Process

5.3.5 Statistical Analysis

Sample size estimation:

Sample size was estimated to be at least 35 participants in each group which was a total of 140 participants. Alpha level was equal to 0.05 with 80% power and an effect size of 0.079.[129] For sample calculation, nQuery Advisor® version 7.0 was used.

Analysis Plan:

Descriptive statistics were reported. Percentages were used to describe categorical data and mean and SD were used to describe quantitative data. Chi-square tests or Fisher's exact test was conducted to determine the association among categorical variables of interest. Student's t-test was conducted to determine differences between continuous variables of interest.

Multiple logistic regression was used to examine the effect of poor sleep quality, sleep medication use, and both after controlling for covariates. The combined effect of poor sleep quality and sleep medication use was assessed by having four categorical variables representing four groups: 1) poor sleep quality and no sleep medication use, 2) good sleep quality and sleep medication use, 3) poor sleep quality and sleep medication use, and 4) good sleep quality and no sleep medication use (the reference group). It was an intent-to-treat analysis. Confounders were identified based on the bivariate association between exposure variables and the outcome variable. However, if a confounder was non-significant, it was still added in the model because of the evidence of a risk factor for falls in the literature. Collinearity was assessed among the predictor variables and covariates in the model. To assess collinearity, correlations among the explanatory variables were assessed. Correlation coefficients larger than 0.9 between the variables meant there was collinearity among the variables. Also, a regression model was performed to use variance inflation factor (VIF) to check for collinearity. A VIF greater than 10 mean there is collinearity among the variables.

The proportion of those who continuously used sleep medications, those who did not use sleep medications for 6 months, and those who started using sleep medications during the follow-up period were reported. The proportion of those who experienced a change in sleep efficiency after 6 months was reported. SAS 9.4 statistical software was used to carry out all

statistical analyses at α=0.05 (SAS Institute Inc., Cary, NC, USA).

5.4 Results

5.4.1 Descriptive Results

A total of 116 participants were recruited between June 2013 and February 2014. During the recruitment process, 19 potential volunteers were excluded during screening primarily because of low MMSE scores. Three participants were lost to follow-up, thus 113 of total participants were available for data analysis. Figure 6.1 is the participants flow chart based on the STROBE (Strengthening the Reporting of Observational Studies in Epidemiology) statement.[130]

The baseline demographic characteristics and covariates are shown in Table 5.2. The study sample had a mean age of 81.08 years (SD=8.57) and approximately 40% of the participants were 85 years or older. The average score on the MMSE was 27.70 (SD=1.70).

Among 113 participants, 46.9% (n=53) fell at least once during 6 months, specifically 23.0% fell once and 23.9% fell more than once. The mean PSQI global score was 6.96 ±3.68. Among participants 62.8% had poor sleep quality (n=71) and 37.2% had good sleep quality (n=42). Of the total participants, 44.2% (n=50) used medications or treatments to aid sleep. Among sleep medication users, 22% used more than one medication or other treatments for sleep.

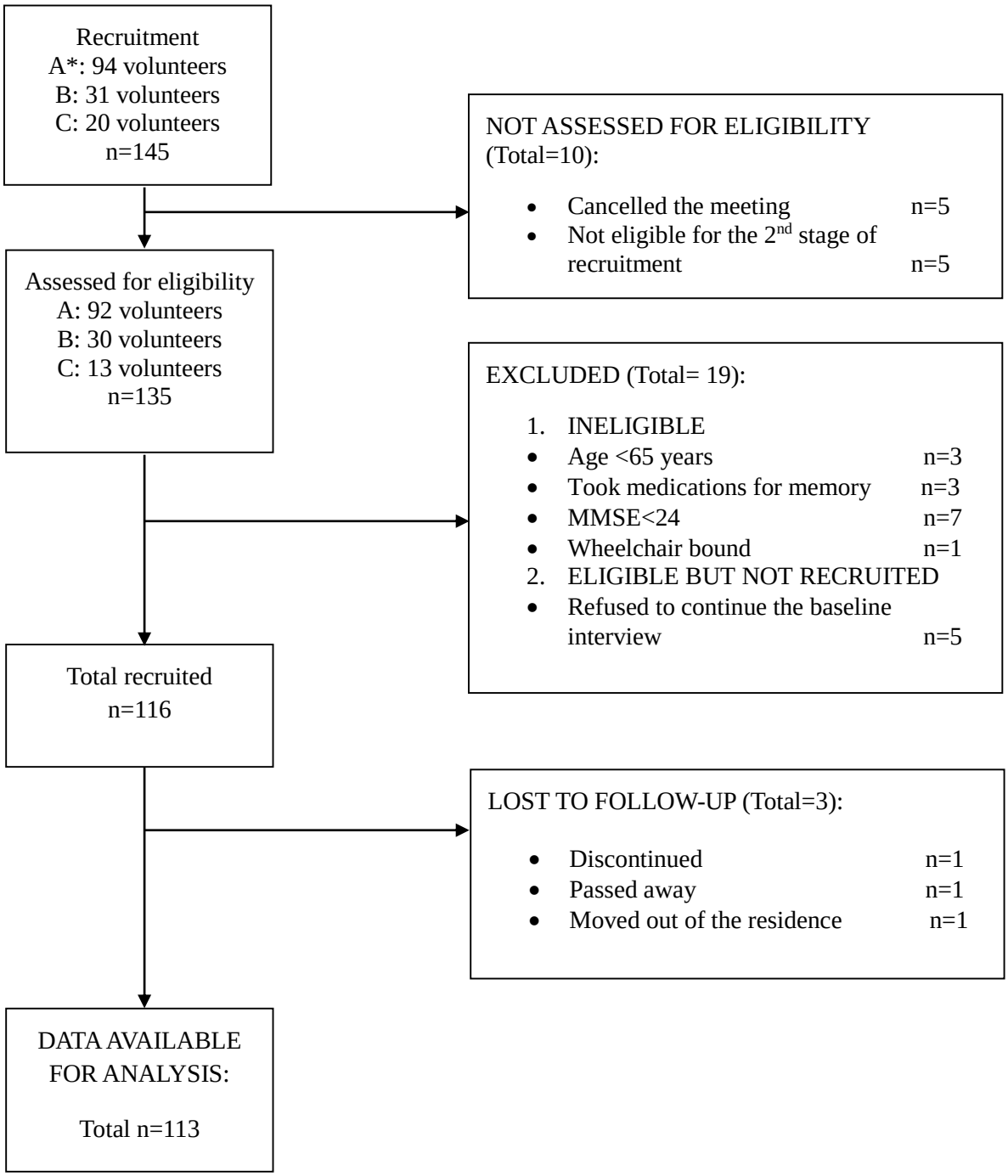

Figure 6.1 Participants Flow Chart[131]

*A, B, and C represent different independent living senior housings.

Table 5.2 Characteristics of Community-Dwelling Older Adults Stratified by Falls, Sleep Quality, and Sleep Medication Use

Variable	Total N (%)	Fallers[a]				Non-fallers			
		Sleep quality[b] (%)		Sleep medication Use[c] (%)		Sleep quality (%)		Sleep medication Use (%)	
		Poor	Good	Yes	No	Poor	Good	Yes	No
Total	113	39	14	29	24	36	24	21	39
Age (years)									
65-74	30 (26.6)	38.5	7.2	48.3	8.3	28.1	17.9	28.6	20.5
75-84	37 (32.7)	33.3	21.4	34.5	25.0	40.6	28.6	47.6	28.2
>85	46 (40.7)	28.2	71.4	17.2	66.7	31.3	53.6	23.8	51.3
Gender									
Male	27 (23.9)	30.8	28.6	34.5	25.0	21.9	85.7	28.6	12.8
Female	86 (76.1)	69.2	71.4	65.5	75.0	78.1	14.3	71.4	87.2
Race									
Caucasian	89 (78.8)	71.8	78.6	69.0	79.2	71.9	95.8	81.0	84.6
Other	24 (21.2)	28.2	21.4	31.0	20.8	28.1	4.2	19.0	15.4
Marital Status									
Married	17(15.0)	12.8	14.3	13.8	12.5	12.5	21.4	28.6	10.3
Other	96 (85.0)	87.2	85.7	86.2	87.5	87.5	78.6	71.4	89.7
Education									
< High School	11 (9.7)	12.8	0	6.9	12.5	12.5	7.1	9.5	10.2
High School	41 (36.3)	38.5	42.9	37.9	41.7	40.6	25.0	23.8	38.5
> High School	61 (54.0)	48.7	57.1	55.2	45.8	46.9	67.9	66.7	51.3
Smoking									
Current smoker	10 (8.9)	12.8	14.3	17.3	8.3	9.4	0	4.7	5.1
Former smoker	48 (42.5)	46.2	35.7	37.9	50.0	40.6	57.1	57.1	33.3
Non-smoker	55 (48.7)	41.0	50.0	44.8	41.7	50.0	42.9	38.1	61.5
FROP-Com*									
Mild falls risk	71 (62.8)	43.6	57.1	44.8	50.0	71.9	82.1	81.0	74.4
Moderate falls risk	36 (31.9)	43.6	35.7	44.8	37.5	28.1	17.9	19.0	25.6
High falls risk	6 (5.3)	12.8	7.2	10.3	12.5	0	0	0	0

*Chi-test, p-value<0.05

a. Fallers= Participants who fell down at least once in the past 6 months

b. Poor sleep quality= PSQI>5

c. Sleep medication Use= Participants who have taken any medications or used other treatments to help sleep in the past month

5.4.2 Sleep Quality Outcomes

There was a statistically significant relationship between quality of sleep and falls (p=0.0262). There was a statistically significant difference in the mean PSQI scores between fallers and non-fallers (t=-3.37, p=0.0011). Fallers had a significantly higher mean score on the PSQI than non-fallers.

The mean and standard deviation of each component of the PSQI is shown in Table 5.3. A higher mean score indicates more difficulty in a given component while a lower mean score indicates less difficulty except for the score on the use of sleeping medication component. Here the higher score indicates higher frequency use of sleep medications in a week compared with a lower score that indicates lower frequency use in a week or no use at all in the past month. Fallers had a higher mean score on the use of sleeping medications and a lower score on daytime dysfunction. Non-fallers had a higher score on sleep disturbance and a lower score on daytime dysfunction. Significant differences in sleep latency, sleep disturbances, use of sleeping medications, and daytime dysfunction between fallers and non-fallers were observed.

Table 5.3 Mean (±SD) on Each Component of the PSQI for Fallers and Non-fallers

Variables	**Total mean (SD)**	**Fallers[a] mean (SD)**	**Non-fallers mean (SD)**	**p-value[b]**
PSQI	6.96 (3.68)	8.17 (3.70)	5.90 (3.07)	0.0009*
Subjective sleep quality	0.80 (0.63)	0.87 (0.68)	0.73 (0.58)	0.2582
Sleep latency	1.23 (1.05)	1.45 (1.12)	1.03 (0.96)	0.0338*
Sleep duration	0.64 (0.98)	0.68 (1.07)	0.60 (0.91)	0.6707
Sleep efficiency	1.09 (1.15)	1.28 (1.23)	0.92 (1.05)	0.0900
Sleep disturbances	1.21 (0.51)	1.32 (0.61)	1.12 (0.37)	0.0324*
Use of sleeping medication	1.23 (1.43)	1.60 (1.49)	0.90 (1.32)	0.0086*
Daytime dysfunction	0.77 (0.69)	0.96 (0.73)	0.60 (0.62)	0.0052*
Total	113	53	60	

a. Fallers= Participants who have fallen down at least once in the past 6 months

b. p-value from t-test between fallers and non-fallers and each component of PSQI

*p-value<0.05

Table 5.4 shows the percentage for fallers and non-fallers on the components of the PSQI. Sleep disturbance and daytime dysfunction components were not included. Fallers had higher percentages of participants with poor sleep quality than non-fallers.

Table 5.4 Percentages on Each Component of the PSQI by for Fallers and Non-fallers

Components	**Total (n=113) N (%)**	**Fallers[b] N (%)**	**Non-fallers N (%)**	**p-value[c]**
PSQI >5[a]	71 (62.8)	39 (73.6)	32 (53.3)	0.0262*
Subjective sleep quality				0.6101
Very good	35 (31.0)	15 (28.3)	20 (33.3)	
Fairly good	67 (59.3)	31 (58.5)	36 (60)	
Fairly bad	10 (8.8)	6 (11.3)	4 (6.7)	
Very bad	1 (0.9)	1 (1.9)	0	
Sleep latency (Minutes to fall asleep)				0.1019
≤15 minutes	42 (37.2)	18 (34.0)	24 (40.0)	
16-30 minutes	46 (40.7)	18 (34.0)	28 (46.7)	
31-60 minutes	13 (11.5)	8 (15.1)	5 (8.3)	
>60 minutes	12 (10.6)	9 (16.9)	3 (5.0)	
Sleep duration				0.5621
>7hours	71 (62.8)	34 (64.1)	37 (61.7)	
6-7 hours	23 (20.4)	9 (17.0)	14 (23.3)	
5-6 hours	8 (7.1)	3 (5.7)	5 (8.3)	
<5hours	11 (9.7)	7 (13.2)	4 (6.7)	
Sleep efficiency				0.1260
>85%	49 (43.4)	20 (37.8)	29 (48.3)	
75-84%	25 (22.1)	12 (22.6)	13 (21.7)	
65-74%	19 (16.8)	7 (13.2)	12 (20.0)	
<65%	20 (17.7)	14 (26.4)	6 (10)	
Use of sleep medications				0.0119*
Not in last month	63 (55.8)	24 (45.3)	39 (65.0)	
Less than once a week	3 (2.7)	0	3 (5.0)	
Once or twice a week	5 (4.4)	2 (3.8)	3 (5.0)	
Three or more times a week	42 (37.2)	27 (50.9)	15 (25.0)	
Total	113	53	60	

a. Poor sleep quality=PSQI>5

b. Fallers=Participants who fell down at least once in the past 6 months

c. p-value: Chi-square or fisher's exact test between fallers and non-fallers and each component of PSQI

*p-value<0.05

5.4.3 Use of Medications or Treatments to Aid Sleep Outcomes

Sleep medication use was significantly associated with falls (p=0.0352). Among sleep medication users, 52.0% used a prescription medication, 10.0% used a nonprescription medication, 12.0% used a herbal products/dietary supplement, 4.0% used alcohol, and 22 % used multiple medications to aid sleep (8.0% used two types of prescription medications, 10.0% used prescription medication with nonprescription medication, 2.0% used nonprescription with herbal, and 2.0% used prescription medication with alcohol). Sleep quality was associated with sleep medication use (p<0.0001). The prevalence of medications and treatments used for sleep is shown in Table 5.5.

Table 5.5 Agents Frequently Used for Sleep

Type of Agents	Top Three Most Frequently Used Agents
Prescription medications	zolpidem (27.5%), trazodone (22.5%), temazepam (10.0%), mirtazapine (10.0%), Other (30.0%)
Nonprescription medications	diphenhydramine (41.7%), OTC PM products (33.3%), doxylamine (16.7%), Other (8.3%)
Herbal products/Dietary supplements	melatonin (85.7%), sleep aid tea (14.3%)
Alcohol	distilled spirits (66.7%), wine (33.3%)

*Percentages within category and only the top three are listed for each type of agent

5.4.4 Falls Outcomes

The mean FROP-Com score of total participants was 10.81 (SD=4.77). Fallers had significantly higher scores (i.e., 12.83±5.00), than non-fallers (i.e., 9.03±3.77) (p<0.0001). According to FROP-Com, the number of falls risk medications, the number of medical conditions, nocturia, balance difficulties, walking ability in the community, and lower level of physical activity were significantly associated with falls in the study population.

Table 5.6 Percentages on Each Risk Factor of Falls Assessed by FROP-Com

Variables	Total N, (%)	Fallers[a] N, (%)	Non-fallers N (%)	p-value[b]
Number of falls in the past 12 months				0.0028*
No falls	67 (59.3)	23 (43.4)	44 (73.3)	
1 fall	31 (27.4)	18 (34.0)	13 (21.7)	
2 falls	11 (9.7)	8 (15.1)	3 (5.0)	
3 or more falls	4 (3.5)	4 (7.6)	0	
An injury in any of the falls in the past 12 months	(n=46) 24 (52.2)	(n=30) 14 (46.7)	(n=16) 10 (62.5)	N.A.
No	13 (28.3)	8 (26.7)	5 (31.3)	
Minor injury, did not require medical attention	7 (15.2)	6 (20.0)	1 (6.3)	
Minor injury, did require medical attention	2 (4.3)	2 (6.6)	0	
Severe injury				
Number of prescription medications				0.0936
No medication	3 (2.7)	1 (1.9)	2 (3.3)	
1-2 medications	15 (13.3)	3 (5.7)	12 (20.0)	
3 medications	5 (4.4)	2 (3.8)	3 (5.0)	
4 or more medications	90 (79.7)	47 (88.7)	43 (71.7)	
Number of falls risk medications[c]				0.0115*
None	10 (23.0)	6 (11.3)	20 (33.3)	
1-2 medications	53 (61.9)	35 (66.0)	35 (58.3)	
3 medications	40 (12.4)	10 (18.9)	4 (6.7)	
4 or more medications	10 (2.7)	2 (3.8)	1 (1.7)	
Type of falls risk medications				N.A.
Sedative	40 (35.4)	24 (45.28)	16 (26.7)	
Antidepressant	32 (28.3)	21 (39.6)	11 (18.3)	
Anti-epileptic	16 (14.2)	6 (11.3)	10 (16.7)	
Central acting analgesic	19 (16.8)	12 (22.6)	7 (11.7)	
Digoxin	4(3.5)	0	4 (6.7)	
Diuretics	38 (33.6)	20 (37.7)	18 (30.0)	
Type 1a antiarrythmic	0	0	0	
Vestibular suppressants	3 (2.7)	2 (3.8)	1 (1.7)	
Number of medical conditions[d]				0.0006*
None	10 (8.9)	3 (5.7)	7 (11.7)	
1-2 conditions	53 (46.9)	17 (32.1)	36 (60.0)	
3-4 conditions	40 (35.4)	29 (54.7)	11 (18.3)	
5 or more conditions	10 (8.8)	4 (7.6)	6 (10.0)	
Type of medical conditions				N.A.
Arthritis	85(75.2)	42 (79.3)	43 (71.7)	
Respiratory condition	13(11.5)	6 (11.3)	7 (11.7)	
Parkinson's disease	0	0	0	
Diabetes	20 (17.7)	13 (24.5)	7 (11.7)	
Dementia	0	0	0	
Peripheral neuropathy	15 (13.3)	9 (17.0)	6 (10.0)	
Cardiac condition	34 (30.1)	20 (37.7)	14 (23.3)	
Stroke	10 (8.9)	6 (11.3)	4 (6.7)	
Other neurological conditions	0	0	0	
Lower limb amputation	0	0	0	

Osteoporosis	26 (23.0)	10 (18.9)	16 (26.7)	
Vestibular disorder	2 (1.8)	1 (1.9)	1 (1.7)	
Other dizziness	16 (14.2)	10 (18.9)	6 (10.0)	
Back pain	18 (15.9)	10 (18.9)	8 (13.3)	
Lower limb joint replacement	28 (24.8)	17 (32.1)	11 (18.3)	
Vision or somatosensory deficits				0.3070
None	87 (77.0)	38 (71.7)	49 (81.7)	
1 deficit	25 (22.1)	14 (26.4)	11 (18.3)	
2 deficits	1 (0.9)	1 (1.9)	0	
Foot problems				0.3775
No	73 (64.6)	32 (60.4)	41 (68.3)	
Yes	40 (35.4)	21 (39.6)	19 (31.7)	
Inappropriate footwear				0.2925
No	94 (83.2)	42 (79.2)	52 (86.7)	
Yes	19 (16.8)	11 (20.8)	8 (13.3)	
Cognitive status				0.7821
9-10 points	98 (86.7)	45 (84.9)	53 (88.3)	
7-8 points	15 (13.3)	8 (15.1)	7 (11.7)	
5-6 points	0	0	0	
4 or less	0	0	0	
Incontinence				0.5280
No	80 (70.8)	17 (32.1)	44 (73.3)	
Yes	33 (29.2)	36 (67.9)	16 (26.7)	
Nocturia				0.0183*
No	86 (76.1)	35 (66.0)	51 (85.0)	
Yes	27 (23.9)	18 (34.0)	9 (15.0)	
Declined food intake in the past three months				0.2522
No	98 (86.7)	44 (83.0)	54 (90.0)	
Small change, but intake remains good	14 (12.4)	9 (17.0)	5 (8.3)	
Moderate loss of appetite	1 (0.9)	0	1 (1.7)	
Severe loss of appetite/ poor oral intake	0	0	0	
Weight loss during the last 3-12 months				0.3656
None	97 (85.8)	44 (83.0)	53 (83.3)	
Minimal (<1 kg) or unsure	13 (11.5)	7 (13.2)	6 (10.0)	
Moderate (1-3 kg)	2 (1.8)	2 (3.8)	0	
Marked (>3 kg)	1 (0.9)	0	1 (1.7)	
Number of alcohol drinks in the past week				0.6838
None	78 (69.0)	39 (73.6)	39 (65.0)	
1-3	19 (16.8)	7 (13.2)	12 (20.0)	
4-10	15 (13.3)	7 (13.2)	8 (13.3)	
11+	1 (0.9)	0	1 (1.7)	
Home environment safety				0.1608
Yes	68 (60.2)	27 (50.9)	41 (68.3)	
Minimal environmental hazards	13 (11.5)	8 (15.1)	5 (8.3)	
Moderate environmental hazards requiring modifications	0 0	0 0	0 0	
Extremely unsafe environment	32 (28.3)	18 (34.0)	14 (23.3)	
Not able to assess				
Observed behaviors in ADL and mobility indication				0.8008
Consistently aware of current abilities/seeks appropriate assistance as required	93 (82.3)	43 (81.1)	50 (83.3)	
Generally aware of current	19 (16.8)	10 (18.9)	9 (15.0)	

abilities/occasional risk-taking behavior				
Under-estimates abilities/inappropriately fearful of activity	0	0	0	
Over-estimates abilities/frequent risk-taking behavior	1 (0.9)	0	1 (1.7)	
Assistance for ADL				0.1001
None (completely independent)	110 (97.4)	50 (94.3)	60 (100)	
Supervision	1(0.9)	1 (1.9)	0	
Some assistance required	2 (1.8)	2 (3.8)	0	
Completely dependent	0	0	0	
Change of ADL after the past fall (n=46)		(n=30)	(n=16)	N.A.
No	45 (97.8)	29 (96.7)	16 (100)	
Yes	1 (2.2)	1 (3.3)	0	
Assistance for IADL				0.9168
None (completely independent)	62 (54.9)	29 (54.7)	33 (55.0)	
Supervision	1(0.9)	0	1 (1.7)	
Some assistance required	49 (43.4)	23 (43.4)	26 (43.3)	
Completely dependent	1 (0.9)	1 (1.9)	0	
Change of IADL after the past fall(n=46)		(n=30)	(n=16)	N.A.
No	45 (97.8)	29 (96.7)	16 (100)	
Yes	1 (2.2)	1 (3.3)	0	
Observation of balance				0.0057*
No unsteadiness observed	77 (68.1)	29 (54.7)	48 (80.0)	
Yes, minimally unsteady on walking or turning	35 (31.0)	23 (43.4)	12 (20.0)	
Yes, moderately unsteady on walking or turning (needs supervision)	1 (0.9)	1(1.9)	0	
Yes, consistently and severely unsteady on walking or turning (needs constant hands on assistance)	0	0	0	
Waking safely in the house				0.0522
Independent, no gait aid needed	88 (77.9)	37 (69.8)	51 (85.0)	
Independent with a gait aid	25 (22.1)	16 (30.2)	9 (15.0)	
Safe with supervision/physical assistance	0	0	0	
Unsafe	0	0	0	
Walking ability in the community				0.0013*
Independent, no gait aid needed	55 (48.7)	17 (32.1)	38 (63.3)	
Independent with a gait aid	57 (50.4)	35 (66.0)	22 (36.7)	
Safe with supervision/physical assistance	1 (0.9)	1 (1.9)	0	
Unsafe	0	0	0	
Aids used (total n=60)				0.0519
None	21 (18.6)	18 (34.0)	35 (58.3)	
Cane	23 (20.4)	14 (26.4)	7 (11.7)	
Walker	14 (12.4)	11 (20.7)	12 (20.0)	
Cane and Walker	2 (1.8)	9 (17.0)	5 (8.3)	
Cane and Scooter		1 (1.9)	1 (1.7)	
Level of physical activity				0.0497*
Very active (exercises 3 times per week)	78 (69.0)	31 (58.5)	47 (78.3)	
Moderately active (exercises less than twice per week)	27 (23.9)	18 (34.0)	9 (15.0)	
Not very active (rarely leaves the house)	8 (7.1)	4 (7.5)	2 (6.7)	
Inactive (rarely leaves one room of the house)	0	0	0	
Change of physical activity after the past falls	(n=46)	(n=30)		N.A.

No	44 (95.7)	28 (93.3)	16 (100)
Yes	2 (4.3)	2 (6.7)	0
Total	113	53	60

a. Fallers=Participants who fell down at least once in the past 6 months

b. p-value=chi-square or fishers' exact test between falls

c. Falls risk medications: Includes sedatives, antidepressants, anti-epileptics, central acting analgesics, digoxin, diuretics, type 1a antiarrythmic, and vestibular suppressants

d. Medical conditions: Includes arthritis, respiratory condition, Parkinson 's disease, diabetes, dementia, peripheral neuropathy, cardiac condition, stroke, other neurological conditions, lower limb amputation, osteoporosis, vestibular disorder, other dizziness, back pain, and lower limb joint replacement

*p-value<0.05

In addition, circumstances of all falls during the 6 months were analyzed. Of 109 total falls, 77.1% falls occurred indoors. Participants were asked for reasons for the falls and 34.9% responded loss of balance. Participants required care in emergency departments or hospitals because of an injury related to the fall in 9.2% of the falls. Only 6.4% of the falls resulted in change in the medications after the fall.

Table 5.7 Circumstances of Falls

Circumstances	**Participants N (%)**
Time of fall	
AM	39 (35.8)
PM	66 (60.5)
Don't know	4 (3.7)
Location of falls	
Living room	32 (29.4)
Kitchen	7 (6.4)
Bedroom	28 (25.7)
Bathroom	15 (13.8)
Community	2 (1.8)
Outside	21 (19.3)
Don't remember	4 (3.7)
Direction of fall	
Sideways	28 (25.7)
Forward	33 (30.3)
Backward	11 (10.1)
Down	22 (20.2)
Can't remember	15 (13.7)
Cause of fall	
Trip	22 (20.2)

Slip	9 (8.3)
Loss of balance	38 (34.9)
Knees gave away	6 (5.5)
Fainted	1 (0.9)
Feeling dizzy or giddy	9 (8.3)
Sleepy	5 (4.6)
Alcohol	1 (0.9)
Fell out of bed	3 (2.7)
Back spasm	1 (0.9)
Unknown	14 (12.8)
Injury after the fall requiring care in ED or hospital	
No	99 (90.8)
Yes	10 (9.2)
Change in medications after the fall	
No	102 (93.6)
Yes	7 (6.4)
Total number of falls	109

5.4.5 Associations between Sleep Medication Use, Sleep Quality, and Falls

Among participants reporting falls, 24.5% reported good sleep quality and no use of sleep medications, 1.9% reported good sleep quality while using of sleep medications, 20.8% reported poor sleep quality but no use of sleep medications, and 52.8% reported poor sleep quality while using sleep medications. Chi-square test showed that all four groups were significantly related to falls (p=0.0262).

Table 5.8 shows the unadjusted relationship between predictor variables, covariates and the outcome variable. Except for FROP-Com, no potential confounding variable was related to the outcome variable. However, all of the covariates were included in the final model based on previous literature. In the unadjusted model, the risk of falls was significantly increased among participants with poor sleep quality and sleep medication use compared with those with good sleep quality and no sleep medication use.

Table 5.8 Unadjusted Relationships of Predictor Variables, and Covariates to the Outcome Variable in the Study Sample

Variable	N (%)	Unadjusted OR (95% CI)
Sleep quality		
Good sleep quality	42 (37.2)	Ref
Poor sleep quality	71 (62.8)	2.44* (1.10-5.39)
Sleep medications		
No sleep medication use	63 (55.8)	Ref
Sleep medication use	50 (44.2)	2.24* (1.05-4.79)
Sleep quality + Sleep medication use		
Good sleep quality + No sleep medications use	36 (31.9)	Ref
Good sleep quality + Sleep medication use	6 (5.3)	0.35 (0.04-3.37)
Poor sleep quality + No sleep medication use	27 (23.9)	1.22 (0.44-3.39)
Poor sleep quality + Sleep medication use	44 (38.9)	3.01* (1.24-7.74)
Age (years)		
65-74	30 (26.6)	Ref
75-84	37 (32.7)	0.67 (0.25-1.76)
>85	46 (40.7)	0.75 (0.29-1.85)
Gender		
Male	27 (23.9)	Ref
Female	86 (76.1)	0.52 (0.22-1.25)
Race		
Caucasian	89 (78.8)	Ref
Other	24 (21.2)	1.80 (0.72-4.47)
Marital Status		
Married	17 (15.0)	Ref
Other	96 (85.0)	1.31 (0.46-3.74)
Education		
Less than High School	11 (9.7)	1.05 (0.29-3.81)
High School	41 (36.3)	1.32 (0.60-2.93)
More than High School	61 (54.0)	Ref
Smoking		
Current smoker	10 (8.9)	3.25 (0.76-13.9)
Former smoker	48 (42.5)	1.28 (0.59-2.79)
Non-smoker (never)	55 (48.7)	Ref
FROP-Com		
Mild falls risk	71 (62.8)	Ref
Moderate falls risk	36 (31.9)	2.89 (1.26-6.62)
High falls risk	6 (5.3)	>999.999 (<0.001-<999.999)

*<0.05

Ref=reference

Table 5.9 reports the relationship between poor sleep, sleep medication use, combination of sleep quality and sleep medication use, and falls. The association was adjusted for the confounding variables listed in Table 5.1. Compared with participants reporting good sleep quality and no sleep medication use, those who reported poor sleep quality and sleep medication use had an increased risk of falls (OR=3.23; 95% CI=1.05-9.91) after adjusting for covariates. The other two groups did not have a significantly greater risk for falls compared to participants reporting good sleep quality and no sleep medication use.

Table 5.9 Adjusted Associations between Predictor Variables and the Outcome Variable

Variables	**N (%)**	**Adjusted OR[a] (95% CI)**
Sleep quality		
Good sleep quality	42 (37.2)	Ref
Poor sleep quality	71 (62.8)	1.92 (0.76-4.85)
Sleep medications		
No sleep medication use	63 (55.8)	Ref
Sleep medication use	50 (44.2)	2.65 (1.04-6.72)*
Sleep quality + Sleep medication use		
Good sleep quality + No sleep medications use	36 (31.9)	Ref
Good sleep quality + Sleep medication use	6 (5.3)	0.52 (0.05-5.80)
Poor sleep quality + No sleep medication use	27 (23.9)	0.87 (0.27-2.83)
Poor sleep quality + Sleep medication use	44 (38.9)	3. 23 (1.05-9.91)*

*<0.05

Ref=reference

a. Full model: Adjusted for age, gender, race, marital status, education, smoking, FROP-Com score

5.4.6 Change in Medication Use and/or Sleep Quality During the Follow-Up Period

After 6 months, one participant in the group of good quality of sleep and sleep medication use stopped using the medication to aid sleep. In the group of poor sleep quality and no use of sleep medications, two participants started medications to aid sleep during the follow-up period. In the group of poor sleep quality and sleep medication use, six participants stopped using medications or treatment for sleep, and two participants had an important change in

sleep efficiency during the follow-up period of 6 months. Among sleep medication users, five participants either changed to a different medication or treatment to aid sleep or added additional medications or treatments to aid sleep during the follow-up period.

5.5 Discussion

5.5.1 Falls in Community-Dwelling Older Adults

The results of the prospective cohort study of community-dwelling older adults showed that 46.9% fell at least once and 23.9% fell more than once during the 6 months. The prevalence was higher than what is commonly reported (i.e., approximately 30% of older adults aged 65 years or older for at least one fall and 50% among those aged 80 years or older for at least one fall in community settings per year).[45] The results were more surprising considering the duration of the current study which was only 6 months, however, the majority of participants were 85 years or older. Older adults who chose or need to live in retirement communities may be more frail or have more functional limitations than those who live independently in their own homes. More falls were reported possibility secondary to having a standardized definition of falls and collecting the falls meticulously by using multiple methods.

Number of falls risk medications, number of medical conditions, nocturia, balance, walking ability in the community, and level of physical activity were significantly associated with falls in FROP-Com. These risk factors, except for nocturia, were included in the AGS/BGS guideline when assessing the fall risk (an evidence-based practice guideline).[46] However, some studies have reported that nocturia is associated with falls in community-dwelling older adults.[132,133]

This study described the circumstances of falls in community-dwelling older adults, including time, location, direction, and cause. In this study, 77.1% of the falls occurred indoors which was higher than previous studies that reported 12-65% of indoor falls.[134–136] This could be related to the living environment where residents do not have to go outside to access many services. Falls occurred mostly in the living rooms and bedrooms. The prevalence of 9.2% injurious falls requiring medical attention was similar to another prospective cohort study with a 6-month follow-up period that reported approximately 10% of community-dwelling older adults being admitted to the hospital after a fall.[137] The majority of the fallers did not change their medications after the falls. For those who had a medication adjustment, pain medications or muscle relaxants were added.

There are various fall risk assessment tools used in assessing community-dwelling older adults. A literature review that evaluated fall risk assessment tools in older adults in different settings recommended using the Timed Up & Go (TUG) and Functional Gait Assessment (FGA) in community-dwelling older adults.[138] The TUG has a specificity of 96.6% and a sensitivity of 83.3% when using a cutoff score of greater than or equal to 12.34 seconds.[138,139] The FGA has a sensitivity of 100% and a specificity of 83% when using a cutoff score of less than or equal to 22/30.[138,139] Compared to these tools, the FROP-Com has lower sensitivity of 67.1% and specificity of 66.7%.[123,138] However, the TUG and FGA are single task performance measures that are more targeted on balance and gait features. Although the sensitivity and specificity are high, it is possible that important information for designing interventions is not collected in these measures.[61] FROP-Com was selected in this study because it was a more comprehensive fall risk assessment that asks about multiple factors related to risk of falls in older adults. Use of multiple-task performance measures may provide more detailed information to understand the multiple risk factors related to falls in

older adults.[61] Moreover, it was chosen because of its applicability in community settings.

There are several methods to document the occurrence of falls (i.e., distributing post-card calendars, making telephone calls or conducting face-to-face interviews).[140–143] A monthly fall diary was used in this study. Advantages of the fall diary include less chance for recall bias than the methods requiring recollection over longer time intervals, and less burden to participants compared with using post-cards that ask participants to mail them at the end of each month. Diaries were checked monthly by the researcher during the follow-up meetings or calls. Some of the disadvantages could be that a participant may forget to record falls for the whole month on the monthly diary, and it could be less precise on collecting falls than weekly calls to the participants. However, considering the difficulties of contacting the participants weekly by telephone calls, and the possibility of more lost to follow-ups by asking the participants to send the post-card diaries, the use of monthly fall diaries was relatively convenient for the researcher and the participants. Since the falls diary was shown to be more precise in collecting falls than retrospective recall over different time periods,[144] it is possible that using monthly fall diaries impacted the number of falls in this study.

5.5.2 Poor Sleep Quality and Medication Use to Aid Sleep in Community-Dwelling Older Adults

Sleep quality was assessed by using the PSQI. The PSQI is a valid instrument that measures sleep disturbances compared with an objective instrument such as polysomnography (PSG)[14,145]. The PSQI include important aspects of sleep disturbance.[122] However, most authors of studies that have assessed the association between poor sleep and falls have formulated their own questions to evaluate sleep problems. Fallers had a

significantly higher mean PSQI global score than non-fallers in our study.

In this study 68.2% of the participants reported poor sleep quality, however, this rate may have been influenced by the recruitment plan. Those who had poorer quality of sleep than others might be more likely to participate in the study. Also, 44.2% of older adults used medications or treatments to aid sleep. Those who were concerned that participation might threaten their access to sleep medications might be less likely to participate in the study. This is related to barriers to participate because falls, sleep, and sleep medication use are sensitive issues in many older adults.

There may be bias when those who participate in the study are different from those who do not participate in the study, and characteristics of older adults who did not participate in this study were not identified. In addition, as the second stage of recruitment, older adults who used any type of agents for sleep problems were specifically recruited and selection bias could have occurred during this process. Selection bias can lead to under-represented or over-represented of certain members of the general population that may challenge the external validity of the study. Thus, as one of the steps to minimize the effects of selection bias, subjects were recruited from multiple study sites including three different congregate senior housing with different demographic and socioeconomic characteristics.

In addition, 22% of sleep medication users took multiple sleep aids, and 40% used potentially inappropriate OTC products and alcohol for sleep. The updated Beers criteria were used to determine potentially inappropriate medications.[146] According to the Beers criteria, diphenhydramine and doxylamine are recommended to be avoided in older adults.[146] In one study of older adults, 30.6% used OTC sleep aids such as Tylenol PM® and 13.0% drank alcohol to treat sleep complaints.[147] Half of those who used OTC sleep aids or alcohol did not consult with their healthcare provider about their sleep problems.[147] In another study,

about 70% of older women treated their sleep problems with OTC medication and alcohol.[148] These results suggest that sleep problems are frequently treated by older adults themselves rather than by the doctors. Moreover, since there is the possibility of under-reporting of alcohol use in this age group,[149] it is possible that more older adults could have used alcohol for poor sleep in this study than was reported.

In reality, use of sleep medications or sleep quality is dynamic. Unlike cross-sectional database studies based on surveys at a single point in time, changes in the usage of sleep medications and sleep efficiency could be observed during the follow-up period. Sleep efficiency was documented instead of sleep quality during the follow up period because of the burden to the participants of administering the PSQI each month. Thus, this study was able to document the change among the four groups over 6 months. Ten participants (8.8%) either had a change in sleep medication use (i.e., started or stopped a medication for sleep) or in sleep efficiency (i.e., an increase from <65% of efficiency to >85% or the other way) after 6 months from the baseline assessments.

5.5.3 Associations between Sleep Medication Use, Poor Sleep Quality, and Falls

In this study, community-dwelling older adults with poor sleep quality were more likely to experience a fall (OR=2.87; 95% CI=1.21-6.78). However, after adjusting for covariates, the association was not significant. Poor sleep quality could lead to falls by causing daytime sleepiness and reduced psychomotor performance,[40] but the association was mitigated after adjusting for other covariates that are associated with falls. On the contrary, the risk of falls was found in older adults who used medications to aid sleep in unadjusted association (OR=2.24; 95% CI=1.05-4.79) and in adjusted association (OR=2.65; 95%

CI=1.04-6.72). This confirms the results of the past systematic literature reviews that showed an increased risk of falls with the use of psychotropic drugs (i.e., sedative hypnotics, benzodiazepines, and antidepressants). In this current study, 52.0% of sleep medication users took prescription medications. The four medications that were most frequently used were zolpidem, trazodone, temazepam, and mirtazapine. Several studies have shown that zolpidem increases risk in falls in adults aged 18 years or older[150] and older adults.[72,73]

Risk of falls was compared among the four groups: 1) poor sleep quality and no sleep medication use, 2) good sleep quality and sleep medication use, 3) poor sleep quality and sleep medication use, and 4) good sleep quality and no sleep medication use. In unadjusted associations, only the group of older adults who had poor sleep quality and used medications for sleep had a significant increase in the risk of falls (OR=3.01; 95% CI=1.24-7.74) compared with the group with good sleep quality and no use of sleep medications. After adjusting for covariates, the risk was slightly increased (OR=3.23; 95% CI=1.05-9.91). Whether or not adjusting for other confounding variables, a significant risk of falls was seen in the group with sleep medication use and poor sleep quality. This shows that continued poor sleep quality while taking sleep medications results in higher risk of falls than either one alone. Risk of falling increases as the number of risk factors increases.[151,152]

The group of older adults with poor sleep quality and no use of sleep medication had no significantly greater risk for falls. The impact of untreated sleep problems on risk of falls may not be as important a problem for community-dwelling older adults. This is consistent with the results of the current study that found a lack of association between poor sleep quality and falls after adjusting for covariates. Similarly, the group of older adults with good sleep quality and sleep medication use had no significantly greater risk for falls. Older adults in this group would mean that their poor sleep quality is well treated with the medications,

thus having a protective effect on falls. This raises the question of whether medication effectiveness is important to consider in understanding the risk of falls for those who use medications or treatments to aid sleep. However, because of the relatively low number of participants in this particular group results must be interpreted with caution.

Still, the results of the study suggest that when poor sleep quality is observed, sleep medication use had an impact on the risk of falls. It may be that the effectiveness of sleep medications is essential to consider when assessing the risk of falls. Perhaps, sleep medication use may have protective effect on risk of falls only when poor sleep is well treated.

In this prospective cohort study, four groups based on poor sleep quality and sleep medication use were formed to better understand whether use of sleep medications, poor sleep quality, both, or neither contribute to risk of falls in older adults. However, there were relatively fewer participants in the group of good sleep quality and use of sleep medications as previously mentioned. This could be because of several reasons. First, it could be a consequence of the effectiveness of medications. Although older adults take medications or treatments for sleep, it is still questionable how effective these agents are for improving sleep because no randomized-controlled study has assessed the effectiveness of the long-term usage of sedative hypnotics in the older adult population. Secondly, if the medications for sleep work well in older adults, it is less likely that individuals would participate in the study because of a fear of changes in their normal medication regimens or daily lives. Thirdly, this could just be a results of the conservative score criteria for the PSQI used in this study. From a score of 0 to 21, a score of more than 5 indicates poor sleep quality. There are seven components in the PSQI and one of them is use of sleep medication. The score is 0 if the respondents did not use any medications or treatments for sleep in the past month, 1 if taken

less than once a week, 2 if taken once or twice a week, and 3 if taken three or more times a week. Thus, the respondents already scored 3 out of 21, if they use any medications for sleep.

Since there was no collinearity among the variables, the sleep medication component in the PSQI will less likely affect the results. If the sleep medication component is deleted in the survey, 31.8% (n=14) of older adults in the group of those with poor sleep quality and sleep medication use, were redefined as those with good sleep quality and sleep medication use with the same scoring criteria. However, since the validity and reliability of the PSQI was evaluated with all seven components of the survey, not considering one component will affect its' validity and reliability. In addition, a different modeling method using the interaction term of sleep quality and sleep medication was conducted, but the results were unchanged.

5.5.4 Strengths and Limitations

Some strengths of this study may be noted. The standardized definition of the outcome falls provided from the WHO was used. Using the standardized definition of the outcome ensured more consistent ascertainment of the outcome and applied the same definition across all participants. Most studies have not included a definition of falls. In the current study, when participants called the researcher to report a fall, the researcher asked several questions derived from the standardized definition to ascertain the fall. This helped to reduce the misclassification bias because the perception of falls varies among people, as some consider it to be a fall only when they fall all the way to the ground or suffer injuries from falls. Moreover, fall diaries were used to collect the outcome. Participants were asked to put a check mark at the end of each week if they had not fallen during the prior week and this helped to reduce recall bias. For monthly follow-up meetings, participants either met every

month or were contacted by phone to determine whether the outcome had occurred. Since participants may forget to report the outcome or forget whether they had an outcome after a long period of time, this helped to reduce the recall bias as well.

There were advantages related to the design of the study. Studies with the outcome of interest being falls have been mostly retrospective in design. Since this was a prospective study, the researcher had more control over the nature and the content of the data collected to answer the research question. This 6-month prospective study collected information on medications that were prescribed for or used by older adults to aid sleep in detail, especially information on sleep aids such as herbals, dietary supplements, and alcohol used for sleep in older adults that is rarely found in retrospective studies. In addition, there is lack of information on poor sleep quality in administrative claims, large federally funded survey databases, and medication records. By using a validated questionnaire, it was possible to measure sleep quality. Also, it was possible to collect information on the specific circumstances of the falls (e.g., time, location, and possible causes). Since the outcome was followed prospectively, there may have been less recall bias in remembering the events compared with retrospective studies. Only three participants were lost to follow-up after 6 months. The researcher was able to track participants who went to the hospital because of an injury from a fall with the help of neighbors and friends. Therefore, it is suggested that there was less bias in the results because of the severity of the falls or fear of reporting a fall. Moreover, a prospective study in design is better at evaluating cause-effect relationships compared with a retrospective study.

During the monthly contacts participants were asked whether they had made any changes in the usage of medications for sleep compared to the regimen from the baseline assessments. They were asked whether they have started any new medications for sleep or

stopped taking medications. Few questions about sleep were asked in the monthly meetings to assess whether there were any changes in sleep efficiency compared to the baseline assessments. Retrospective studies typically assess the exposure variables only during the baseline assessments. Thus, any changes in the groups over the 6 month follow up period were possible to detect in this study.

This was the only known study to evaluate the association between poor sleep quality, sleep medication use, and falls in community-dwelling adults aged 65 years or above. There was one study that evaluated the association between insomnia, hypnotic use, and falls in older adults residing in nursing homes that found greater risk of falls in those with insomnia but no use of hypnotics, and in those with insomnia and use of hypnotics compared with those with no insomnia and no use of hypnotics.[40]

There are some limitations of this study. The aim of the study was to find the association in community-dwelling older adults and included older adults residing in three independent senior housing with residents of different socioeconomic and demographic status. However, a majority of the participants in this study were white females and 40% of the total participants were 85 years or older. Thus, the results may not be entirely generalizable to other older adult groups.

In addition, all the information that was collected was self-reported that may lead to misclassification bias. Any type of medications or treatments that were used for sleep was collected by conducting medication reviews. Participants either brought the actual medications that they took within the past month or showed medical prescriptions during the interview. However, participants might have not reported the agents they took for sleep because they forgot to report or reported the agents differently from the agents that they actually took. In addition, indications of medications were solely determined based on the

verbal confirmation of the participants. Because most of the indications of the medications were self-reported, it is possible that there were errors in the reporting and the medications were actually intended to be used for different purposes. For example, mirtazapine was reported to be either used for sleep or depression leading to different categorization of the participants, however, this type of potential miscategorization affected only a few participants. On the contrary, self-reporting of the indication of the medications has enabled us to capture the variety of the medications or treatments that patients claim that they were using to aid sleep.

Information on medication dose was not accounted for in the analysis. For example, the Drug Burden Index (DBI), a measure of exposure to anticholinergic and sedative medications that considers dosage was not calculated.[153] However, this study found that nine of the participants used 10 mg of zolpidem for sleep problems once daily before bedtime used more than the recommended dose in geriatric patients.

Furthermore, the PSQI was used to assess poor sleep quality among participants. It is a self-reported method that is more subjective compared with using actinography or medical diagnosis. However, the procedures of assessments using the survey were the same across the participants by following a script and by having only two researchers administering the study during the study. The outcome of falls was also self-reported. Fall diaries were distributed and monthly contacts to the participants were conducted, however there could still be participants who might have forgotten to report the outcome.

Lastly, the total number of the participants in this study was less than in most retrospective studies that used large databases or medical records. Although multiple recruitment strategies were performed, it is possible that some older adults were concerned about participating in a research study generally or because they might receive some

unwanted treatments or disadvantages from participating. Retention of the participants was also crucial in this study. Three participants (2.6%) from the group of poor sleep quality and no sleep medication use were lost to follow-up. Although it was a small percentage, their falls could have affected the results of the study considering the total number of participants.

5.6 Conclusion

This study explored the independent effect of poor sleep quality, sleep medication use, and their combined effect on the risk of falls. Older adults with poor sleep quality and sleep medication use had a significantly the higher risk of falls compared with those with good sleep quality and no sleep medication use. Poor sleep quality in spite of sleep medication use has increased the risk of falls. In other words, the combined effect of poor sleep quality and sleep medication use increased the risk of falls more than the individual effects alone. More prospective studies are needed to confirm the results of this study.

Chapter 6

Conclusion and Future Research

6.1 Conclusion

The research underlying this dissertation focused on the association between medications used for sleep, poor sleep, and falls in community-dwelling older adults. The cross-sectional database study assessed the prevalence of sleep problems, sleep medication use, and falls in older adults. Having sleep problems was significantly associated with a risk of falls compared with not having sleep problems. Older adults were grouped by sleep problems and use of sleep medication. The risk was seen in all the groups compared to those with no sleep problems and no sleep medication use. The highest risk was found in older adults with no sleep problems and sleep medication use that may suggest that sleep medication use did not have a protective effect on risk of falls.

The prospective cohort study showed that poor sleep quality did not predict a significantly higher risk for future falls, while use of sleep medications predicted a higher risk. When compared with older adults with good sleep quality and no use of sleep medications, the risk of falls was only found in older adults who had poor sleep quality and use of sleep medications after controlling for covariates. The risk was not found in the other two groups: 1) older adults with good sleep quality and sleep medication use, and 2) those with poor sleep quality with no sleep medication use.

Possible reasons for the difference in findings between the cross-sectional study and the prospective cohort study would be the difference in the study design and measurement of study variables.

In conclusion, the results of the both studies suggest that poor sleep added to sleep medication use increased the risk of falls in community-dwelling older adults. The research undertaken in this dissertation provided evidence for a significant risk of falls associated with the combined effect of poor sleep and sleep mediation use.

It is important to consider medication-associated risk when treating sleep problems in older adults. Since older adults with poor sleep quality in spite of sleep medication use have greater risk of falls, it further suggests that medication effectiveness may be an important factor to consider in understanding the risk of falls associated with medications agents used for sleep. Health care professionals should assess the effects of sleep medication use on poor sleep quality to achieve better health outcomes. This study filled a gap in the current literature by untangling confounding by indication of poor sleep quality, sleep medication use, and falls in community-dwelling older adults.

6.2 Future Research

Future investigators should consider conducting this study with a larger sample size. Future studies may include more independent senior housings communities with a longer recruitment period to accomplish this. With a larger sample size, the risk of falls in older adults with no sleep problems and use of medications or treatments for sleep could be confirmed.

Additionally, a subgroup analysis could be performed between the types of medications or even among different therapeutic classes to further compare the risk of falls. This would enable clarification of the inconsistent results on the association between some commonly used agents for sleep and falls in this population.

Lastly, survival analysis could be conducted to assess the cumulative risk of falls because a history of a fall is one of the risk factors for future falls. Further analyses on the risk of recurrent falls and injurious falls in prospective studies would be valuable.

References

1. Bloom HG, Ahmed I, Alessi CA, et al. Evidence-based recommendations for the assessment and management of sleep disorders in older persons. *J Am Geriatr Soc*. 2009;57(5):761-789.

2. Anderer P, Moreau A, Woertz M, et al. Computer-assisted sleep classification according to the standard of the American Academy of Sleep Medicine: validation study of the AASM version of the Somnolyzer 24 × 7. *Neuropsychobiology*. 2010;62(4):250-264.

3. Crowley K. Sleep and sleep disorders in older adults. *Neuropsychol Rev*. 2011;21(1):41-53.

4. Avidan AY. Sleep disorders in the older patient. *Prim Care*. 2005;32(2):563-586.

5. Ohayon MM, Carskadon MA, Guilleminault C, Vitiello MV. Meta-analysis of quantitative sleep parameters from childhood to old age in healthy individuals: developing normative sleep values across the human lifespan. *Sleep*. 2004;27(7):1255-1273.

6. Collop NA, Salas RE, Delayo M, Gamaldo C. Normal sleep and circadian processes. *Crit Care Clin*. 2008;24(3):449-60.

7. Pace-Schott EF, Spencer RM. Age-related changes in the cognitive function of sleep. *Prog Brain Res*. 2011;191:75-89.

8. Ancoli-Israel S, Ayalon L, Salzman C. Sleep in the elderly: normal variations and common sleep disorders. *Harv Rev Psychiatry*. 2008;16(5):279-286.

9. Ancoli-Israel S, Ayalon L. Diagnosis and treatment of sleep disorders in older adults. *Am J Geriatr Psychiatry*. 2006;14(2):95-103.

10. St George RJ, Delbaere K, Williams P, Lord SR. Sleep quality and falls in older people living in self- and assisted-care villages. *Gerontology*. 2009;55(2):162-168.

11. Foley DJ, Monjan AA, Brown SL, Simonsick EM, Wallace RB, Blazer DG. Sleep complaints among elderly persons: an epidemiologic study of three communities. *Sleep*. 1995;18(6):425-432.

12. Foley D, Ancoli-Israel S, Britz P, Walsh J. Sleep disturbances and chronic disease in older adults: results of the 2003 National Sleep Foundation Sleep in America Survey. *J Psychosom Res*. 2004;56(5):497-502.

13. Janssens JP, Pautex S, Hilleret H, Michel JP. Sleep disordered breathing in the elderly. *Aging (Milano)*. 2000;12(6):417-429.

14. 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.

15. Brassington GS, King AC, Bliwise DL. Sleep problems as a risk factor for falls in a sample of community-dwelling adults aged 64-99 years. *J Am Geriatr Soc*. 2000;48(10):1234-1240.

16. Barbar SI, Enright PL, Boyle P, et al. Sleep disturbances and their correlates in elderly Japanese American men residing in Hawaii. *Journals Gerontol A, Biol Sci Med Sci*. 2000;55(7):M406-11.

17. Crenshaw MC, Edinger JD. Slow-wave sleep and waking cognitive performance among older adults with and without insomnia complaints. *Physiol Behav*. 1999;66(3):485-492.

18. Grunstein R. Insomnia. Diagnosis and management. *Aust Fam Physician*. 2002;31(11):995-1000.

19. Bain KT. Management of chronic insomnia in elderly persons. *Am J Geriatr Pharmacother*. 2006;4(2):168-192.

20. Kamel NS, Gammack JK. Insomnia in the elderly: cause, approach, and treatment. *Am J Med*. 2006;119(6):463-469.

21. Glass J, Lanctot KL, Herrmann N, Sproule BA, Busto UE. Sedative hypnotics in older people with insomnia: meta-analysis of risks and benefits. *BMJ*. 2005;331(7526):1169.

22. Salzman C. Pharmacologic treatment of disturbed sleep in the elderly. *Harv Rev Psychiatry*. 2008;16(5):271-278.

23. Ancoli-Israel S, Cooke JR. Prevalence and comorbidity of insomnia and effect on functioning in elderly populations. *J Am Geriatr Soc*. 2005;53(7 Suppl):S264-71.

24. National Sleep Foundation Web site. 2003 National Sleep in America Poll. http://sleepfoundation.org/sites/default/files/2003SleepPollExecSumm.pdf. Accessed September 30, 2014.

25. US Food and Drug Administration. FDA approves new type of sleep drug, Belsomra. http://www.fda.gov/NewsEvents/Newsroom/PressAnnouncements/ucm409950.htm. Accessed October 16, 2014.

26. Minkel J, Krystal AD. Optimizing the pharmacologic treatment of insomnia: current status and future horizons. *Sleep Med Clin*. 2013;8(3):333-350.

27. Stewart R, Besset A, Bebbington P, et al. Insomnia comorbidity and impact and hypnotic use by age group in a national survey population aged 16 to 74 years. *Sleep*. 2006;29(11):1391-1397.

28. Sanna E, Busonero F, Talani G, et al. Comparison of the effects of zaleplon, zolpidem, and triazolam at various GABA(A) receptor subtypes. *Eur J Pharmacol*. 2002;451(2):103-110.

29. Taylor SR, Weiss JS. Review of insomnia pharmacotherapy options for the elderly: implications for managed care. *Popul Health Manag*. 2009;12(6):317-323.

30. McCall WV, Erman M, Krystal AD, et al. A polysomnography study of eszopiclone in elderly patients with insomnia. *Curr Med Res Opin*. 2006;22(9):1633-1642.

31. Scharf M, Erman M, Rosenberg R, et al. A 2-week efficacy and safety study of eszopiclone in elderly patients with primary insomnia. *Sleep*. 2005;28(6):720-727.

32. Ebert B, Wafford KA, Deacon S. Treating insomnia: current and investigational pharmacological approaches. *Pharmacol Ther*. 2006;112(3):612-629.

33. Roth T, Seiden D, Wang-Weigand S, Zhang J. A 2-night, 3-period, crossover study of ramelteon's efficacy and safety in older adults with chronic insomnia. *Curr Med Res Opin*. 2007;23(5):1005-1014.

34. Ioachimescu OC, El-Solh AA. Pharmacotherapy of insomnia. *Expert Opin Pharmacother*. 2012;13(9):1243-1260.

35. Zisapel N. Drugs for insomnia. *Expert Opin Emerg Drugs*. 2012;17(3):299-317.

36. Yamashita H, Mori K, Nagao M, Okamoto Y, Morinobu S, Yamawaki S. Influence of aging on the improvement of subjective sleep quality by atypical antipsychotic drugs in patients with schizophrenia: comparison of middle-aged and older adults. *Am J Geriatr Psychiatry*. 2005;13(5):377-384.

37. Zammit GK. The prevalence, morbidities, and treatments of insomnia. *CNS Neurol Disord Drug Targets*. 2007;6(1):3-16.

38. Peretti CS, Danion JM, Kauffmann-Muller F, Grangé D, Patat A, Rosenzweig P. Effects of haloperidol and amisulpride on motor and cognitive skill learning in healthy volunteers. *Psychopharmacology (Berl)*. 1997;131(4):329-338.

39. Obermeyer W, Benca R. Effect of drugs on sleep. *Otolarynqol Clin North Am*. 1999;32(2):289-302.

40. Avidan AY, Fries BE, James ML, Szafara KL, Wright GT, Chervin RD. Insomnia and hypnotic use, recorded in the minimum data set, as predictors of falls and hip fractures in Michigan nursing homes. *J Am Geriatr Soc*. 2005;53(6):955-962.

41. Mah L, Upshur RE. Long term benzodiazepine use for insomnia in patients over the age of 60: discordance of patient and physician perceptions. *BMC Fam Pract*. 2002;3:9.

42. Stel VS, Pluijm SM, Deeg DJ, Smit JH, Bouter LM, Lips P. A classification tree for predicting recurrent falling in community-dwelling older persons. *J Am Geriatr Soc*. 2003;51(10):1356-1364.

43. Tromp AM, Smit JH, Deeg DJ, Bouter LM, Lips P. Predictors for falls and fractures in the Longitudinal Aging Study Amsterdam. *J Bone Miner Res*. 1998;13(12):1932-1939.

44. Clyburn TA, Heydemann JA. Fall prevention in the elderly: analysis and comprehensive review of methods used in the hospital and in the home. *J Am Acad Orthop Surg*. 2011;19(7):402-409.

45. Inouye SK, Brown CJ, Tinetti ME. Medicare nonpayment, hospital falls, and unintended consequences. *N Engl J Med*. 2009;360(23):2390-2393.

46. American Geriatrics Society and British Geriatrics Society Panel on Prevention of Falls in Older Persons. Summary of the Updated American Geriatrics Society/British Geriatrics Society clinical practice guideline for prevention of falls in older persons. *J Am Geriatr Soc*. 2011;59(1):148-157.

47. Rubenstein LZ, Josephson KR, Robbins AS. Falls in the nursing home. *Ann Intern Med*. 1994;121(6):442-451.

48. Weir E, Culmer L. Fall prevention in the elderly population. *CMAJ*. 2004;171(7):724.

49. Donaldson MG, Khan KM, Davis JC, et al. Emergency department fall-related presentations do not trigger fall risk assessment: a gap in care of high-risk outpatient fallers. *Arch Gerontol Geriatr*. 2005;41(3):311-317.

50. Centers for Disease Control and Prevention. WISQARS (Web-based Injury Statistics Query and Reporting System). http://www.cdc.gov/injury/wisqars/. Accessed November 17, 2014.

51. Carroll N V, Slattum PW, Cox FM. The cost of falls among the community-dwelling elderly. *J Manag Care Pharm*. 2005;11(4):307-316.

52. Stevens JA, Corso PS, Finkelstein EA, Miller TR. The costs of fatal and non-fatal falls among older adults. *Inj Prev*. 2006;12(5):290-295.

53. Hester AL, Wei F. Falls in the community: state of the science. *Clin Interv Aging*. 2013;8:675-679.

54. World Health Organization. WHO Global Report on Falls Prevention in Older Age. http://www.who.int/ageing/publications/Falls_prevention7March.pdf. Accessed September 14, 2014.

55. Lamb SE, Jorstad-Stein EC, Hauer K, Becker C, Group P of FNE and OC. Development of a common outcome data set for fall injury prevention trials: the Prevention of Falls Network Europe consensus. *J Am Geriatr Soc*. 2005;53(9):1618-1622.

56. Ory MG, Schechtman KB, Miller JP, et al. Frailty and injuries in later life: the FICSIT trials. *J Am Geriatr Soc*. 1993;41(3):283-296.

57. Van Nieuwenhuizen RC, van Dijk N, van Breda FG, et al. Assessing the prevalence of modifiable risk factors in older patients visiting an ED due to a fall using the CAREFALL Triage Instrument. *Am J Emerg Med*. 2010;28(9):994-1001.

58. Fabre JM, Ellis R, Kosma M, Wood RH. Falls risk factors and a compendium of falls risk screening instruments. *J Geriatr Phys Ther*. 2010;33(4):184-197.

59. Tinetti ME, Kumar C. The patient who falls: "It's always a trade-off." *JAMA*. 2010;303(3):258-266.

60. Deandrea S, Lucenteforte E, Bravi F, Foschi R, La Vecchia C, Negri E. Risk factors for falls in community-dwelling older people: a systematic review and meta-analysis. *Epidemiology*. 2010;21(5):658-668.

61. Persad CC, Cook S, Giordani B. Assessing falls in the elderly: should we use simple screening tests or a comprehensive fall risk evaluation? *Eur J Phys Rehabil Med*. 2010;46(2):249-259.

62. Woolcott JC, Richardson KJ, Wiens MO, et al. Meta-analysis of the impact of 9 medication classes on falls in elderly persons. *Arch Intern Med*. 2009;169(21):1952-1960.

63. Bloch F, Thibaud M, Dugué B, et al. Psychotropic drugs and falls in the elderly people: updated literature review and meta-analysis. *J Aging Health*. 2011;23(2):329-346.

64. Ray WA. Psychotropic drugs and injuries among the elderly: a review. *J Clin Psychopharmacol*. 1992;12(6):386-396.

65. Cummings SR, Rubin SM, Black D. The future of hip fractures in the United States. Numbers, costs, and potential effects of postmenopausal estrogen. *Clin Orthop Relat Res*. 1990;(252)(252):163-166.

66. Ford GA, Hoffman BB, Blaschke TF. Effect of temazepam on blood pressure regulation in healthy elderly subjects. *Br J Clin Pharmacol*. 1990;29(1):61-67.

67. Allain H, Bentue-Ferrer D, Polard E, Akwa Y, Patat A. Postural instability and consequent falls and hip fractures associated with use of hypnotics in the elderly: a comparative review. *Drugs Aging*. 2005;22(9):749-765.

68. Leipzig RM, Cumming RG, Tinetti ME. Drugs and falls in older people: a systematic review and meta-analysis: I. Psychotropic drugs. *J Am Geriatr Soc*. 1999;47(1):30-39.

69. Ensrud KE, Blackwell TL, Mangione CM, et al. Central nervous system-active medications and risk for falls in older women. *J Am Geriatr Soc*. 2002;50(10):1629-1637.

70. Landi F, Onder G, Cesari M, et al. Psychotropic medications and risk for falls among community-dwelling frail older people: an observational study. *Journals Gerontol A, Biol Sci Med Sci*. 2005;60(5):622-626.

71. Pariente A, Dartigues JF, Benichou J, Letenneur L, Moore N, Fourrier-Reglat A. Benzodiazepines and injurious falls in community dwelling elders. *Drugs Aging*. 2008;25(1):61-70.

72. Chang CM, Chen MJ, Tsai CY, et al. Medical conditions and medications as risk factors of falls in the inpatient older people: a case-control study. *Int J Geriatr Psychiatry*. 2011;26(6):602-607.

73. Rhalimi M, Helou R, Jaecker P. Medication use and increased risk of falls in hospitalized elderly patients: a retrospective, case-control study. *Drugs Aging*. 2009;26(10):847-852.

74. Zammit G, Wang-Weigand S, Rosenthal M, Peng X. Effect of ramelteon on middle-of-the-night balance in older adults with chronic insomnia. *J Clin Sleep Med*. 2009;5(1):34-40.

75. Zammit G, Schwartz H, Roth T, Wang-Weigand S, Sainati S, Zhang J. The effects of ramelteon in a first-night model of transient insomnia. *Sleep Med*. 2009;10(1):55-59.

76. Darowski A, Chambers SACF, Chambers DJ. Antidepressants and falls in the elderly. *Drugs Aging*. 2009;26(5):381-394.

77. Kerse N, Flicker L, Pfaff JJ, et al. Falls, depression and antidepressants in later life: a large primary care appraisal. *PLoS One*. 2008;3(6):e2423.

78. Hill KD, Wee R. Psychotropic drug-induced falls in older people: a review of interventions aimed at reducing the problem. *Drugs Aging*. 2012;29(1):15-30.

79. Quach L, Yang FM, Berry SD, et al. Depression, antidepressants, and falls among community-dwelling elderly people: the MOBILIZE Boston study. *J Gerontol A Biol Sci Med Sci*. 2013;68(12):1575-1581.

80. Masud T, Frost M, Ryg J, et al. Central nervous system medications and falls risk in men aged 60-75 years: the Study on Male Osteoporosis and Aging (SOMA). *Age Ageing*. 2013;42(1):121-124.

81. Carbone LD, Johnson KC, Robbins J, et al. Antiepileptic drug use, falls, fractures, and BMD in postmenopausal women: findings from the women's health initiative (WHI). *J Bone Miner Res*. 2010;25(4):873-881.

82. Mendelson WB, Roth T, Cassella J, et al. The treatment of chronic insomnia: drug indications, chronic use and abuse liability. Summary of a 2001 New Clinical Drug Evaluation Unit meeting symposium. *Sleep Med Rev*. 2004;8(1):7-17.

83. Sakamoto Y, Ebihara S, Ebihara T, et al. Fall prevention using olfactory stimulation with lavender odor in elderly nursing home residents: a randomized controlled trial. *J Am Geriatr Soc*. 2012;60(6):1005-1011.

84. Reid MC, Boutros NN, O'Connor PG, Cadariu A, Concato J. The health-related effects of alcohol use in older persons: a systematic review. *Subst Abus*. 2002;23(3):149-164.

85. Sorock GS, Chen LH, Gonzalgo SR, Baker SP. Alcohol-drinking history and fatal injury in older adults. *Alcohol*. 2006;40(3):193-199.

86. Cawthon PM, Harrison SL, Barrett-Connor E, et al. Alcohol intake and its relationship with bone mineral density, falls, and fracture risk in older men. *J Am Geriatr Soc*. 2006;54(11):1649-1657.

87. Mukamal KJ, Mittleman MA, Longstreth WT, Newman AB, Fried LP, Siscovick DS. Self-reported alcohol consumption and falls in older adults: cross-sectional and longitudinal analyses of the cardiovascular health study. *J Am Geriatr Soc*. 2004;52(7):1174-1179.

88. Stenbacka M, Jansson B, Leifman A, Romelsjo A. Association between use of sedatives or hypnotics, alcohol consumption, or other risk factors and a single injurious fall or multiple injurious falls: a longitudinal general population study. *Alcohol*. 2002;28(1):9-16.

89. Mohanty M. *Alcohol and Medication Use in Community-Dwelling Older Adults: Understanding the Effect of Alcohol and Central Nervous System-Acting Medications on the Risk for Falls* [dissertation]. Richmond, VA: Virginia Commonwealth Univerisity; 2013.

90. Moher D, Liberati A, Tetzlaff J, Altman DG, Group P. Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. *PLoS Med*. 2009;6(7):e1000097.

91. Higgins J, Green S. Cochrane Handbook for Systematic Reviews of Interventions Version 5.1.0 [updated March 2011]. *Cochrane Collab*. 2011. http://www.cochrane.org/handbook. Accessed September 15, 2014.

92. Wells GA, Shea B, O'Connell D, et al. The Newcastle-Ottawa Scale (NOS) for assessing the quality of nonrandomised studies in meta-analyses. http://www.ohri.ca/programs/clinical_epidemiology/oxford.asp. Accessed September 15, 2014.

93. Herzog R, Alvarez-Pasquin MJ, Diaz C, Del Barrio JL, Estrada JM, Gil A. Are healthcare workers' intentions to vaccinate related to their knowledge, beliefs and attitudes? A systematic review. *BMC Public Health*. 2013;13:154.

94. Helbig AK, Döring A, Heier M, et al. Association between sleep disturbances and falls among the elderly: results from the German Cooperative Health Research in the Region of Augsburg-Age Study. *Sleep Med*. 2013;14(12):1356-1363.

95. Teo JS, Briffa NK, Devine A, Dhaliwal SS, Prince RL. Do sleep problems or urinary incontinence predict falls in elderly women? *Aust J Physiother*. 2006;52(1):19-24.

96. Byles JE, Mishra GD, Harris MA, Nair K. The problems of sleep for older women: changes in health outcomes. *Age Ageing*. 2003;32(2):154-163.

97. Hill EL, Cumming RG, Lewis R, Carrington S, Le Couteur DG. Sleep disturbances and falls in older people. *Journals Gerontol Ser A Biol Sci Med Sci*. 2007;62A(1):62-66.

98. Endeshaw Y. Correlates of self-reported nocturia among community-dwelling older adults. *journals Gerontol A, Biol Sci Med Sci*. 2009;64(1):142-148.

99. Stone KL, Ewing SK, Lui LY, et al. Self-reported sleep and nap habits and risk of falls and fractures in older women: the study of osteoporotic fractures. *J Am Geriatr Soc*. 2006;54(8):1177-1183.

100. Stone KL, Ancoli-Israel S, Blackwell T, et al. Actigraphy-measured sleep characteristics and risk of falls in older women. *Arch Intern Med*. 2008;168(16):1768-1775.

101. Mesas AE, Lopez-Garcia E, Rodriguez-Artalejo F. Self-reported sleep duration and falls in older adults. *J Sleep Res*. 2011;20(1 Pt 1):21-27.

102. Kuo HK, Yang CCH, Yu YH, Tsai KT, Chen CY. Gender-specific association between self-reported sleep duration and falls in high-functioning older adults. *Journals Gerontol A, Biol Sci Med Sci*. 2010;65A(2):190-196.

103. Grundstrom AC, Guse CE, Layde PM. Risk factors for falls and fall-related injuries in adults 85 years of age and older. *Arch Gerontol Geriatr*. 2012;54(3):421-428.

104. Gassmann KG, Rupprecht R, Freiberger E, Group IZGS. Predictors for occasional and recurrent falls in community-dwelling older people. *Z Gerontol Geriatr*. 2009;42(1):3-10.

105. Kaushik S, Wang JJ, Mitchell P. Sleep apnea and falls in older people. *J Am Geriatr Soc*. 2007;55(7):1149-1150.

106. Cirillo DJ, Wallace RB. Restless legs syndrome and functional limitations among American elders in the Health and Retirement Study. *BMC Geriatr*. 2012;12:39.

107. Schlesinger A, Redfern MS, Dahl RE, Jennings JR. Postural control, attention and sleep deprivation. *Neuroreport*. 1998;9(1):49-52.

108. Cohen-zion M, Stepnowsky C, Marler, Shochat T, Kripke DF, Ancoli-Israel S. Changes in cognitive function association with sleep disordered breathing in older people. *J AM Geriatr Soc*. 2001;49(12):1622-1627.

109. Alapin I, Fichten CS, Libman E, Creti L, Bailes S, Wright J. How is good and poor sleep in older adults and college students related to daytime sleepiness, fatigue, and ability to concentrate? *J Psychosom Res*. 2000;49(5):381-390.

110. Bliwise NG. Factors related to sleep quality in healthy elderly women. *Psychol Aging*. 1992;7(1):83-88.

111. Moden B, Merlo J, Ohlsson H, Rosvall M. Psychotropic drugs and falling accidents among the elderly: a nested case control study in the whole population of Scania, Sweden. *J Epidemiol Community Health*. 2010;64(5):440-446.

112. Servais M. Overview of HRS public data files for cross-sectional and longitudinal analysis. *Surv Res Center, Inst Soc Res, University of Michigan*. June, 2004. http://scholar.google.com/scholar?hl=en&btnG=Search&q=intitle:Overview+of+HRS+Public+Data+Files+for+Cross-sectional+and+Longitudinal+Analysis#0. Accessed July 10, 2014.

113. Health and Retirement Study. http://hrsonline.isr.umich.edu/index.php. Accessed August 16, 2014.

114. Chen TY, Janke MC. Predictors of falls among community-dwelling older adults with cancer: results from the health and retirement study. *Support Care Cancer*. 2014;22(2):479-485.

115. Gure TR, McCammon RJ, Cigolle CT, Koelling TM, Blaum CS, Langa KM. Predictors of self-report of heart failure in a population-based survey of older adults. *Circ Cardiovasc Qual Outcomes*. 2012;5(3):396-402.

116. Kerr EA, Heisler M, Krein SL, et al. Beyond comorbidity counts: how do comorbidity type and severity influence diabetes patients' treatment priorities and self-management? *J Gen Intern Med*. 2007;22(12):1635-1640.

117. Guideline for the prevention of falls in older persons. American Geriatrics Society, British Geriatrics Society, and American Academy of Orthopaedic Surgeons Panel on Falls Prevention. *J Am Geriatr Soc*. 2001;49(5):664-672.

118. Gaines JM, Poey JL, Marx KA, Parrish JM, Resnick B. Health and medical services use: a matched case comparison between CCRC residents and national health and retirement study samples. *J Gerontol Soc Work*. 2011;54(8):788-802.

119. Tromp AM, Pluijm SM, Smit JH, Deeg DJ, Bouter LM, Lips P. Fall-risk screening test: a prospective study on predictors for falls in community-dwelling elderly. *J Clin Epidemiol*. 2001;54(8):837-844.

120. Bleijlevens MHC, Diederiks JPM, Hendriks MRC, van Haastregt JCM, Crebolder HFJM, van Eijk JTM. Relationship between location and activity in injurious falls: an exploratory study. *BMC Geriatr*. 2010;10:40.

121. Hanlon JT, Boudreau RM, Roumani YF, et al. Number and dosage of central nervous system medications on recurrent falls in community elders: the Health, Aging and Body Composition study. *J Gerontol A Biol Sci Med Sci*. 2009;64(4):492-498.

122. Cole JC, Dubois D, Kosinski M. Use of patient-reported sleep measures in clinical trials of pain treatment: a literature review and synthesis of current sleep measures and a conceptual model of sleep disturbance in pain. *Clin Ther*. 2007;29 Suppl:2580-2588.

123. Russell MA, Hill KD, Blackberry I, Day LM, Dharmage SC. The reliability and predictive accuracy of the falls risk for older people in the community assessment (FROP-Com) tool. *Age Ageing*. 2008;37(6):634-639.

124. Groll DL, To T, Bombardier C, Wright JG. The development of a comorbidity index with physical function as the outcome. *J Clin Epidemiol*. 2005;58(6):595-602.

125. Rawsky E. Review of the literature on falls among the elderly. *Image J Nurs Sch*. 1998;30(1):47-52.

126. Dunlop DD, Manheim LM, Sohn M-W, Liu X, Chang RW. Incidence of functional limitation in older adults: the impact of gender, race, and chronic conditions. *Arch Phys Med Rehabil*. 2002;83(7):964-971.

127. Stevens JA, Sogolow ED. Gender differences for non-fatal unintentional fall related injuries among older adults. *Inj Prev*. 2005;11(2):115-119.

128. Gill T, Taylor AW, Pengelly A. A population-based survey of factors relating to the prevalence of falls in older people. *Gerontology*. 2005;51(5):340-345.

129. Oliver D, Connelly JB, Victor CR, et al. Strategies to prevent falls and fractures in hospitals and care homes and effect of cognitive impairment: systematic review and meta-analyses. *BMJ*. 2007;334(7584):82.

130. Vandenbroucke JP, von Elm E, Altman DG, et al. Strengthening the Reporting of Observational Studies in Epidemiology (STROBE): explanation and elaboration. *PLoS Med*. 2007;4(10):e297.

131. Hay AD, Wilson A, Fahey T, Peters TJ. The duration of acute cough in pre-school children presenting to primary care: a prospective cohort study. *Fam Pract*. 2003;20(6):696-705.

132. Vaughan CP, Brown CJ, Goode PS, Burgio KL, Allman RM, Johnson TM. The association of nocturia with incident falls in an elderly community-dwelling cohort. *Int J Clin Pract*. 2010;64(5):577-583.

133. Parsons JK, Mougey J, Lambert L, et al. Lower urinary tract symptoms increase the risk of falls in older men. *BJU Int*. 2009;104(1):63-68.

134. Carter SE, Campbell EM, Sanson-fisher RW, Gillespie WJ. Accidents in older people living at home: a community-based study assessing prevalence, type, location and injuries. *Aust N Z J Public Heal*. 2000;24(6):633-636.

135. Kojima S, Furuna T, Ikeda N, Nakamura M, Sawada Y. Falls among community-dwelling elderly people of Hokkaido, Japan. *Geriatr Gerontol Int*. 2008;8(4):272-277.

136. Kelsey JL, Berry SD, Procter-Gray E, et al. Indoor and outdoor falls in older adults are different: the maintenance of balance, independent living, intellect, and Zest in the Elderly of Boston Study. *J Am Geriatr Soc*. 2010;58(11):2135-2141.

137. Hill A-M, Hoffmann T, Haines TP. Circumstances of falls and falls-related injuries in a cohort of older patients following hospital discharge. *Clin Interv Aging*. 2013;8:765-774.

138. Lee J, Geller AI, Strasser DC. Analytical review: focus on fall screening assessments. *PM R*. 2013;5(7):609-621.

139. Wrisley DM, Kumar NA. Functional gait assessment: concurrent, discriminative, and predictive validity in community-dwelling older adults. *Phys Ther*. 2010;90(5):761-773.

140. Quach L, Galica AM, Jones RN, et al. The nonlinear relationship between gait speed and falls: the Maintenance of Balance, Independent Living, Intellect, and Zest in the Elderly of Boston Study. *J Am Geriatr Soc*. 2011;59(6):1069-1073.

141. Allan LM, Ballard CG, Rowan EN, Kenny RA. Incidence and prediction of falls in dementia: a prospective study in older people. *PLoS One*. 2009;4(5):e5521.

142. Puts MT, Monette J, Girre V, et al. The fall rate of older community-dwelling cancer patients. *Support Care Cancer*. 2012;21(3):775-783.

143. Stone CA, Lawlor PG, Savva GM, Bennett K, Kenny RA. Prospective study of falls and risk factors for falls in adults with advanced cancer. *J Clin Oncol*. 2012;30(17):2128-2133.

144. Hannan MT, Gagnon MM, Aneja J, et al. Optimizing the tracking of falls in studies of older participants: comparison of quarterly telephone recall with monthly falls calendars in the MOBILIZE Boston Study. *Am J Epidemiol*. 2010;171(9):1031-1036.

145. Blanco J, Zamarrón C, Abeleira Pazos MT, Lamela C, Suarez Quintanilla D. Prospective evaluation of an oral appliance in the treatment of obstructive sleep apnea syndrome. *Sleep Breath*. 2005;9(1):20-25.

146. The American Geriatrics Society 2012 Beers Criteria Update Expert Panel. American Geriatrics Society updated Beers Criteria for potentially inappropriate medication use in older adults. *J Am Geriatr Soc*. 2012;60(4):616-631.

147. Gooneratne NS, Tavaria A, Patel N, et al. Perceived effectiveness of diverse sleep treatments in older adults. *J Am Geriatr Soc*. 2011;59(2):297-303.

148. Johnson JE. Sleep problems and self-care in very old rural women: nursing implications. *Geriatr Nurs*. 1996;17(2):72-74.

149. Sorocco KH, Ferrell SW. Alcohol use among older adults. *J Gen Psychol*. 2006;133(4):453-467.

150. Kolla BP, Lovely JK, Mansukhani MP, Morgenthaler TI. Zolpidem is independently associated with increased risk of inpatient falls. *J Hosp Med*. 2013;8(1):1-6.

151. Tinetti ME, Speechley M, Ginter SF. Risk factors for falls among elderly persons living in the community. *N Engl J Med*. 1988;319(26):1701-1707.

152. Tinetti M, Baker D, McAvay G, et al. A mulfitactorial intervention to reduce the risk of falling among elderly people living in the community. *N Engl J Med*. 1994;331(13):821-827.

153. Hilmer S, Mager D, Simonsick E, Cao Y, Ling S, Windham G. A drug burden index to define the functional burden of medications in older people. *Arch Intern Med*. 2007;167(8):781-787.

Appendix A

Search Algorithms for the Systematic Review of the Association between Poor Sleep and Falls in Community-Dwelling Older Adults

Pubmed/Medline

The search algorithms combined three domains: (Sleep OR sleep problems) AND Falls.

1. sleep[MeSH]

2. sleep[Text Word]

3. sleep disorders[MeSH]

4. sleep disorders[Text Word]

5. 1 or 2 or 3 or 4

6. accidental falls[Mesh]

7. falls[Text Word]

8. 6 or 7

9. 5 and 8

("Sleep"[Mesh] OR "sleep disorders"[Mesh] OR “sleep”[tw] OR “sleep disorders”[tw]) AND

("accidental falls"[Mesh] OR “falls”[tw])

CINAHL

(MH "Sleep+") OR "sleep" OR (MH "sleep disorders+") OR "sleep disorders"

AND (MH "accidental falls") OR "falls"

PsyINFO

Any Field: ((IndexTerms:("Falls")) OR Subject:("accidental falls" OR "falls") AND

PublicationYear:[0 TO 2013]) *AND* **Any Field**: ((IndexTerms:("Hypersomnia") OR

IndexTerms:("Insomnia") OR IndexTerms:("Kleine Levin Syndrome") OR

IndexTerms:("NREM Sleep") OR IndexTerms:("Napping") OR IndexTerms:("Narcolepsy") OR IndexTerms:("Parasomnias") OR IndexTerms:("REM Sleep") OR IndexTerms:("Sleep") OR IndexTerms:("Sleep Disorders") OR IndexTerms:("Sleepwalking")) OR Subject:("Hypersomnia" OR "Insomnia" OR "Kleine Levin Syndrome" OR "NREM Sleep" OR "Napping" OR "Narcolepsy" OR "Parasomnias" OR "REM Sleep" OR "Sleep" OR "Sleep Disorders" OR "Sleepwalking") AND PublicationYear:[0 TO 2013])

Appendix B
Research Subject Information and Consent Form

RESEARCH SUBJECT INFORMATION AND CONSENT FORM

TITLE: The Risk of Falls in Older Adults with Poor Sleep Quality

VCU IRB NO.: HM15169

If any information contained in this consent form is not clear, please ask the study staff to explain any information that you do not fully understand. You may take home an unsigned copy of this consent form to think about or discuss with family or friends before making your decision.

PURPOSE OF THE STUDY

The purpose of this research study is to learn about the risk of falls in adults aged 65 years or older to determine if there is an association between poor sleep quality, medications prescribed for or used by patients to aid sleep, and a combination of these factors, on the risk of falls in older adults. You are being asked to participate in this study because you are aged 65 or older, able to read and converse in English, and expect to reside at a congregate senior housing community for six months after the study initiation.

DESCRIPTION OF THE STUDY AND YOUR INVOLVEMENT

If you decide to be in this research study, you will be asked to sign this consent form after you have had all your questions answered and understand what will happen to you.

At your first interview, you will be asked to answer questionnaires to evaluate your sleep quality, risk of falls, and health conditions. We will also review your medications that you have used within the past month. It will take approximately one hour. These tests will take place in a private office area at the Pharmacy Clinic or at your residence based on your preference. We will provide you with a fall calendar to help you record your falls and we will ask you to call the researcher within 48 hours if you have a fall.

Every month for six months, we will arrange to meet with you briefly at the Pharmacy Clinic or at your residence based on your preference. At the meeting, we will collect your fall calendar and ask you a few questions to see if there have been any changes with your sleep quality and your current medications for sleep. This will take approximately ten minutes. Your participation in this study will last for up to six months after our initial interview.

No personal information about you will be revealed to staff or residents of the Imperial Plaza during or after the study.

Significant new findings developed during the course of the research which may relate to your willingness to continue participation will be provided to you.

RISKS AND DISCOMFORTS

The questionnaires of sleep quality, fall risks, and other health conditions that you have will take about 30 minutes to complete. The administration will be conducted in a private office area at the Pharmacy Clinic or at your home at your preference. If you want to take a break, you can do so between different tests. If you feel exhausted at any time, you can stop the testing session.

The questionnaires you will take may show you are at a high risk for a fall. If so, we will let you know after the testing session and encourage you to seek help from your primary care physician.

In addition, the medications that you have taken in the past month will be reviewed. Information collected about your medications will be confidential. It will not be disclosed to staff or residents of Imperial Plaza.

There is also a minimal risk of transmitting your personal identifying information to persons not on the study team. However, we will minimize this risk by keeping it in a secure place that only study personnel have access to and immediately destroying this information once we are finished with the study.

BENEFITS TO YOU AND OTHERS

There is no direct benefit to you for participating in this study. However, what is learned from this study may help older adults to identify and/or prevent the risk of falls by understanding the relationship between sleep quality, medications to aid sleep and falls.

COSTS

There are no costs for participating in this study other than the time you will spend in the visits.

PAYMENT FOR PARTICIPATION

You will receive a $10 VISA® gift card for completing the questionnaires on your first interview. You will receive additional $25 VISA® gift card at the last visit after 6 months for a total of $35 in the form of VISA® gift cards after you completed all the study follow-up visits. VISA® gift cards can be used wherever VISA debit cards are accepted. The cards cannot be reloaded or used at ATM machines for cash withdrawals.

You may be asked to provide your social security number in order to receive payment for your participation. Your social security number is required by federal law. It will not be included in any information collected about you for this research.
Your social security number will be kept confidential and will only be used in order to process payment.

ALTERNATIVES

Your alternative is not to participate in this study.

CONFIDENTIALITY

Information about your age, gender and alcohol consumption for sleep in addition to your results of sleep quality, fall risk, other health conditions, medication regimen from the medication review, and number of falls from the fall calendar is being collected for only for research purposes.

Your data will be identified by an ID number, not your name, and stored in a locked research area and a secured computerized database at VCU. All personal identifying information will be kept in password protected files and these files will be deleted after the last follow-up meeting. Access to all data will be limited to study personnel who have undergone special training on maintaining confidentiality of individuals participating in research.

We will not tell anyone the answers you give us; however, information from the study and the consent form signed by you may be looked at or copied for research or legal purposes by Virginia Commonwealth University. Additionally, if we suspect that someone is hurting you, the law says that we have to let people in authority know so they can protect you.

What we find from this study may be presented at meetings or published in papers, but your name will not ever be used in these presentations or papers.

VOLUNTARY PARTICIPATION AND WITHDRAWAL

You do not have to participate in this study. Your decision not to take part will involve no penalty or loss of benefits to which you are otherwise entitled. If you choose to participate, you may stop at anytime without any penalty or loss of benefits to which you are otherwise entitled. You may also choose not to answer particular questions that are asked in the study.

Your participation in this study may be stopped at any time without your consent. The reasons might include, but not limited to, that you have not followed study instructions, there are administrative reasons require your withdrawal, or that we have stopped the study.

QUESTIONS
If you have any questions, complaints, or concerns about your participation in this research, contact:

Patricia W. Slattum, PharmD, PhD
Director, Geriatric Pharmacotherapy Program
Department of Pharmacotherapy and Outcomes Science
Virginia Commonwealth University
410 N 12th Street, Smith Building, Room 656A
Richmond, VA 23298-0533
PO BOX 980533
(804) 828-6355

The researcher named above is the best person to call for questions about your participation in this study.

If you have any general questions about your rights as a participant in this or any other research, you may contact:

Office of Research
Virginia Commonwealth University
800 East Leigh Street, Suite 3000
P.O. Box 980568
Richmond, VA 23298
Telephone: (804) 827-2157

Contact this number for general questions, concerns or complaints about research. You may also call this number if you cannot reach the research team or if you wish to talk with someone else. General information about participation in research studies can also be found at http://www.research.vcu.edu/irb/volunteers.htm.

CONSENT

I have been given the chance to read this consent form. I understand the information about this study. Questions that I wanted to ask about the study have been answered. My signature says that I am willing to participate in this study. I will receive a copy of the consent form once I have agreed to participate.

Participant name printed	Participant signature	Date

Name of Person Conducting Informed Consent Discussion / Witness (Printed)

Signature of Person Conducting Informed Consent Discussion / Witness — Date

Principal Investigator Signature (if different from above) — Date

Approved
4-29-13 LRU / JK

Appendix C

Study Advertisement Flyer

ATTENTION!

Are you interested participating in our research?

OFFICE OF RESEARCH
rec'd
APR 3 2013
SUBJECT PROTECTION
Approved
4-29-13/LRC/JOR

- **Are you aged 65 years ?**
- **Are you able to read and converse in English?**
- **Do you expect to reside at the community for at least 6 months after the study initiation?**

If YES, you are eligible to participate!

Participants will spend not longer than **1 hour of being interviewed either at the Pharmacy Clinic or at your home** at a time convenient for you!

Participants will receive **$35 compensation**

Please contact Dr. Patricia Slattum, PharmD, PhD, Virginia Commonwealth University School of Pharmacy, (804)828-6355, pwslattu@vcu.edu

3-15-2013

Dr. Patricia Slattum
(804) 828-6355
pwslattu@vcu.edu

Apendix D

Study Brochure

The Risk of Falls in Older Adults with Poor Sleep Quality

Volunteers Needed!

Participants will receive **$35** compensation!

Virginia Commonwealth University, School of Pharmacy

3-15-2013

OFFICE OF RESEARCH SUBJECT PROTECTION rec'd APR 3 2013

Approved 4-29-13

Dr. Patricia Slattum, PharmD, PhD

VCU School of Pharmacy
410 N. 12th Street
BOX 980533
Richmond, VA 23298-0533

Phone: (804) 828-6355
E-mail: pwslattu@vcu.edu

- Information about you is being collected for research purpose only.
- Information collected from you will be confidential
- Access to all data will be limited to study personnel.
- No change in your medications will be made as part of this study.

What is the Purpose?

The purpose of the study is to learn about the risk of falls in older adults aged 65 or older.

The Study has been approved by the VCU Institutional Review Board

What do you have to do?

First Interview:

- Participate in one interview to answer questionnaires and review your medications
- The interview will not take longer than 1 hour
- It can be scheduled at the Pharmacy Clinic or at your home at your convenience

Monthly Meetings:

- You will receive a fall calendar to record when you have fallen
- The interview will not take longer than 10 minutes
- It can be scheduled at the Pharmacy Clinic or at your home at your convenience

Who can participate?

You can participate if you are :

- Aged 65 years or older
- Able to read and converse in English
- Expect to reside at the community for at least 6 months after the study initiation

For more information, please contact

Dr.Patricia Slattum

VCU School of Pharmacy
410 N. 12th Street
BOX 980533
Richmond, VA 23298-0533

Phone: (804) 828-6355
E-mail: pwslattu@vcu.edu

Approved
4-29-13 LEC JR

3-15-2013

Appendix E

Subject ID: _____

Date: _____

Basic Demographics

1. What is your age? _____

2. Gender

   - Male
   - Female

3. What is your race?

   - White
   - Black or African-American
   - American Indian or Alaska Native
   - Asian
   - Native Hawaiian or Other Pacific Islander

4. What is your highest level of education?

   - Less than High School
   - High School graduate/GED
   - Associate's degree
   - Bachelor's degree
   - Advanced degree

5. Do you smoke or have you smoked?

   - I have never smoked before

   - I used to smoke
     - How many years ago did you quit? _____
     - How many years did you smoke? _____
     - On average, how many packs-per-day did you smoke? _____

   - I currently smoke
     - How many years have you been smoking? _____
     - On average, how many packs-per-day do you smoke? _____

Appendix F

Subject ID: _____

Date: _____

Medication Review

What type of prescription medications have you used within the past month?

PRESCRIPTION MEDICATION

Name	**Strength (Dose)**	**Indication** *What do you take the medication for?*	**Frequency** *How many times a day do you take the medication?*

What type of nonprescription medications have you used within the past month? Nonprescription medications are medications that can be bought from over the counter without a prescription from your doctor. And have you used any herbal aids or dietary supplements such as vitamins within the past month?

NONPRESCRIPTION MEDICATION/HERBAL AIDS/DIETARY SUPPLEMENTS

Name	**Strength (Dose)**	**Indication**	**Frequency**

Appendix G

Subject ID: _____

Date: _____

Questions about Alcohol Intake for Sleep

1. Have you used alcohol in the past week? Yes/No

2. Have you used alcohol in the past month? Yes/No

→*If answered "Yes", continue asking the following questions. If answered "No", stop asking.*

3. Have you used alcohol to help you sleep in the past month? Yes/No

→*If answered "No", ask again, "you haven't used any beer or wine to help you fall asleep?"*

4. Which alcohol have you used for sleep problems in the past month?

→*Circle the option based on the answers.*

Beer
Wine
Sherry
Distilled Spirits (whiskey, gin, tequila, rum, vodka, or other distilled spirits)
Other

5A. Thinking about your past month, about how many days per week did you use alcohol to help you sleep?

1) 6-7 times a week

2) 4-5 times a week

3) 2-3 times a week

4) Once a week

5) Less than once a week (on special occasions)

5B. During those days, on average, how many drinks did you have per day?

(A 'standard' drink is equal to 12 ounces of regular beer, 5 ounces of table wine, or 1.5 ounces of hard liquor/spirits)

1) 5 or more drinks

2) 3-4 drinks

3) 1-2 drinks

4) Less than one drink

Appendix H

Subject ID: _____

Date: _____

The Functional Comorbidity Index (FCI)

Circle the specific disease and calculate the total score.
Do you have any of the following conditions?

1. _____Arthritis (rheumatoid and osteoarthritis)
2. _____Osteoporosis
3. _____Asthma
4. _____Chronic obstructive pulmonary disease (COPD), acquired respiratory distress syndrome (ARDS), or emphysema
5. _____Angina
6. _____Congestive heart failure (or heart disease)
7. _____Heart attack (myocardial infarct)
8. _____Neurological disease (such as multiple sclerosis or Parkinson's or other neurological conditions: _____)
9. _____Stroke or TIA
10. _____Peripheral vascular disease or Peripheral neuropathy

11. _____Diabetes types I and II
12. _____Upper gastrointestinal disease (ulcer, hernia, reflux)
13. _____Depression
14. _____Anxiety or panic disorders
15. _____Visual impairment (such as cataracts, glaucoma, macular degeneration)
16. _____Hearing impairment (very hard of hearing, even with hearing aids)
17. _____Degenerative disc disease (back disease, spinal stenosis, or severe chronic back pain)

18. _____Obesity and/or body mass index > 30 (weight in kg/height in meters^2)
    height_____(cm or inches?)
    weight_____(kg or lbs?) BMI=
19. _____Vestibular disorder
20. _____Other dizziness
21. _____Lower limb amputation
22. _____Lower limb joint replacement

Total score (number of check marks from #1-18): _____
(Abbreviations: TIA= transient ischemic attack)

Groll DL, To T, Bombardier C, Wright JG. The development of a comorbidity index with physical function as the outcome. *J Clin Epidemiol*. 2005 Jun;58(6):595-602.

Appendix I

Subject ID: _____
Date: _____

Monthly Follow-Up Questions

Following questions will be asked by the researcher to the participants verbally.

A Question for Subjective Sleep Quality

1. During the past month, what time have you usually gone bed at night? _____

2. During the past month, what time have you usually gotten up in the morning? _____

3. During the past month, how many hours of actual sleep did you get at night? (This may be different than the number of hours you spent in bed.) _____

4. During the past month, how would you rate your sleep quality overall?

1) Very good

2) Fairly Good

3) Fairly bad

4) Very bad

Questions for Treatments to Aid Sleep

1. Are you still taking *(refer to the medication for sleep)* that you reported last month? Yes/No

→*If No, skip #2.*

2. Did you change the dosage or frequency of _____ that you reported last month? Yes/No

→ *Remind the dosage and frequency that were reported last month. If 'yes', what dosage are you taking now and how many times a day do you take the medication?*

_____

→ *Proceed to #3.*

3. Have you started taking any new medications for sleep or switched to a different medication for sleep from what you have reported last month? Yes/No

→*If 'yes' ask the name, dosage and frequency of intake.* _____

Fall Questionnaire

These questions will also be asked during the monthly meetings in case the participant did not call the researcher within 48hours after a fall.

1. Did you have a fall in the past month? Yes/No

2. Did you fall more than once in the past month? Yes/No

Ask question As if the person fell only once and ask question Bs if the person fell more than once.

3A. Was it intentional? Yes/No

3B. Among any of the falls, were any of those intentional? Yes/No *(Record them as first, second fall and so on)*

4A. Did you touch the ground floor or other lower level when you fell? Yes/No

4B. Among any of the falls, did you touch the ground floor or other lower level when you fell? Yes/No *(Record them as first, second fall and so on)*

5A. Can you please describe the circumstances of the recent fall?

5B. Can you please describe the circumstances of all the falls? *(→Time, location, and whether they think they have a reason for the fall).*

6A. Did you make any changes in medications before or after the fall? Yes/No

6B. Among any of the falls, did you make any changes in medications before or after the falls? Yes/No *(→If answered 'yes', please describe.)*

Appendix J
The Fall Diary

June 2013

Sun	Mon	Tue	Wed	Thu	Fri	Sat
						1 ☐
2	3	4	5	6	7	8 ☐
9	10	11	12	13	14	15 ☐
16	17	18	19	20	21	22 ☐
23	24	25	26	27	28	29 ☐
30						

Notes: Jun 16: Father's Day

Put a ✓ at the end of each week **if you had not fallen** during the prior **7** days!

When a fall occurred, please ☎ the researcher! (571) 482-0183

Appendix K

Subject ID: _____

Date: _____

Fall Questionnaire

These questions will be asked when the participant calls the researcher to report a fall.

1. Did you fall on ___day? Yes/No

(→If the participant told the researcher that he/she had a fall on a particular day, double check with this question)

2. Was it intentional? Yes/No

3. Did you touch the ground floor or other lower level when you fell? Yes/No

4. Can you please describe the circumstances of the recent fall?

(→Time, location, and whether they think they have a reason for the fall).

5. Did you make any changes in medications before or after the fall? Yes/No

(→If answered 'yes', please describe.)

Curriculum Vitae

Yaena Min

116 East Franklin Street #601, Richmond, VA 23219 • (517) 482-0183 • miny@vcu.edu

EDUCATION

PhD Candidate (Expected Graduation: December 2014) Aug. 2010-Present
Department of Pharmacotherapy and Outcomes Science
School of Pharmacy, Virginia Commonwealth University, Richmond, VA

- Dissertation title: "The Effect of Sleep Medication Use and Poor Sleep Quality on Risk of Falls in Community-Dwelling Older Adults"

Graduate Certificate in Aging Studies (Expected Graduation: December 2014) Aug. 2010-Present
Department of Gerontology
Virginia Commonwealth University, Richmond, VA

Bachelor of Science – Pharmacy Feb. 2009
College of Pharmacy, Chung-Ang University, Seoul, Korea

Study Abroad – Pre-Pharmacy Aug.-Dec.2006
University of Nebraska at Kearney, Kearney, NE

EXPERIENCE

Graduate Research Assistant Aug. 2014-Present
School of Pharmacy, Virginia Commonwealth University, Richmond, VA

- Research interest: Geriatric pharmacotherapy, patient-reported outcomes, health policy, sleep problems and other mental health conditions

Research Assistant Jan.2012-Feb.2013
School of Pharmacy, Virginia Commonwealth University, Richmond, VA
"Data collection in Postoperative Cognitive Dysfunction (POCD) Research"

- Assisted in developing surveys for patient data collection
- Conducted patient informed consents and follow-up visits
- Administered paper-based and computer-based surveys

Graduate Teaching Assistant Aug. 2011-Aug. 2014
School of Pharmacy, Virginia Commonwealth University, Richmond, VA

- Assisted faculty in preparation to begin each semester and designed a Blackboard website
- Evaluated and assisted pharmacy students in patient counseling
- Created problem sets and exam questions for the epidemiology course

Retail Pharmacist Feb. 2010-Aug. 2010
Korea Pharmacy, Cheongju, Korea

- Educated consumers and patients on the use of prescription medications/over-the-counter medications, and dispensed prescription medications

Hospital Pharmacist March 2009-Dec. 2009
Chungbuk National University Hospital, Cheongju, Korea

- Provided medication counseling to out-patients

- Provided medication counseling to patients in the emergency department during the night shifts
- Dispensed medications for in-patients and out-patients

Pharmacy Trainee Aug. 2006-Nov. 2006
Walgreens Pharmacy, Kearney, NE

PUBLICATIONS

- Donohoe KL, Yunkder NS, Morgan L, **Min Y**, Patel P. An Active-Learning Laboratory on Respiratory Devices
  –Submitted to the *Currents in Pharmacy Teaching and Learning* in June 2014 (In review).
- **Min Y**, Slattum PW. Poor Sleep and Risk of Falls in Community-Dwelling Older Adults: A Systematic Review
  –Submitted to the *Journal of Applied Gerontology* in November 2014.
- **Min Y**, Zentgraf WM, Slattum PW. Medication Use for Treating Poor Sleep in Community-Dwelling Older Adults
  –In preparation to be submitted to *The Consultant Pharmacist* in December 2014.

EDITORIAL ACTIVITY

- Reviewed one and co-reviewed one manuscript for **The Annals of Pharmacotherapy** (2011, 2012)

RESEARCH PRESENTATIONS

- Zentgraf WM, **Min Y**, Slattum PW. Medication use for the treatment of insomnia in independently living older adults. Presented at The Annual Meeting and Exhibition of the *American Society of Consultant Pharmacists* (ASCP), National Harbor, Maryland. November 6-9, 2012. Also presented at VCU School of Pharmacy Research and Career Day, Richmond, VA. October 12, 2012.
- **Min Y**, Holdford DA. Cost-Effectiveness of Apixaban and Dabigatran for Preventing Death Due to Stroke from the Medicare Perspective. Presented at VCU School of Pharmacy Research and Career Day, Richmond, VA. November 8, 2013.
- **Min Y**, Slattum PW, Nadpara PA. The Association Between Sleep Problems, Sleep Medications, and Falls in Community-Dwelling Older Adults: Results from the Health and Retirement Study 2010. Abstract accepted and will be presented at the *International Society for Pharmacoeconomics and Outcomes Research* (ISPOR) 19th Annual International Meeting, Montreal, QC, Canada, May 31-June 4, 2014.
- Donohoe K, Yunker N, Morgan L, **Min Y**, Patel P. An Active-Learning Laboratory on Respiratory Devices. Abstract accepted and will be presented at the *American Association of Colleges of Pharmacy* (AACP) Annual Meeting, Pharmacy Education, Grapevine, TX, July 26-30, 2014.
- **Min Y**, Slattum PW. Untangling Confounding by Indication: Poor Sleep, Sleep Medications and Falls (abstract, submitted and in review). Symposium presentation for "Understanding Associations of Medicines with Geriatric Syndromes: Implications for Prescribing and Deprescribing" to the *Gerontological Society of America's* 67th Annual Scientific Meeting, Washington DC, November 5-9, 2014.
- **Min Y**, Slattum PW. The Effect of Sleep Medication Use and Poor Sleep Quality on Risk of Falls in Community-Dwelling Older Adults. Presented at VCU School of Pharmacy Research and Career Day, Richmond, VA. October 17, 2014. Also will be presented at the *Gerontological Society of America* (GSA) 67th Annual Scientific Meeting, Washington DC, November 5-9 2014.

LICENSURE & CERTIFICATION

- Registered Pharmacist in South Korea Feb. 2009-Present
- Certificate in Clinical Pharmacy e-Learning Dec.2009
  Korean Society of Health-System Pharmacist, Seoul, Korea
- Certificate in SPSS program, Chungbuk National University, Cheongju, Korea Feb.2010

PROFESSIONAL MEMBERSHIP

- The Gerontological Society of America 2014-Present
- International Society for Pharmacoeconomics and Outcomes Research (ISPOR) 2012-Present
- Virginia Geriatrics Society (VGS) 2012-Present

HONORS AND AWARDS

- **The 2014 Victor A. Yanchick Award, VCU School of Pharmacy** May 2014
  - In recognition of having achieved the greatest distinction in the areas of scholarship, research, and service in the Department of Pharmacotherapy and Outcomes Science
- **Who's Who Among Students in American Universities and Colleges Award** April 2014
  - Selected on the basis of academic achievement, services to the community, leadership in extracurricular activities and future potential
- **Rho Chi National Pharmacy Honor Society, Lambda Chapter** April 2014-Present
- **Alpha Epsilon Lambda National Honor Society** April 2013-Present

LEADERSHIP EXPERIENCE

- **Professional and Personal Development Program (PPDP)** Sep.2012-April 2014
  School of Pharmacy, VCU, Richmond, VA
  - Actively participated in a pilot program for 4 semesters with a goal to develop leadership abilities and to partake in professional development opportunities
  - Scholarship awarded by Altria Group

- **Secretary/Treasurer** Aug.2012-Aug.2013
  Graduate Student Association, VCU, Richmond, VA
  Served as Department of Pharmacotherapy and Outcomes Science liaison to GSA

- **Treasurer** Aug.2012-Aug.2013
  International Society for Pharmacoeconomics and Outcomes Research (ISPOR)
  Student Chapter
  VCU, Richmond, VA

SPECIAL ACKNOWLEDGEMENT

- Interviewed for the Virginia Commonwealth University Home Page Feb. 2014
  - Graduate dissertation research acknowledged by VCU for contributing to the community
  - *Better together: VCU graduate students make a lasting impact on the local community and vice versa* www.news.vcu.edu/students/Better_together

UNIVERSITY SERVICE

- **Student Member of the Promotion & Tenure Committee** Sep.2013-Nov.2013
  School of Pharmacy, Virginia Commonwealth University, Richmond, VA
  - Reviewed teaching documents, accumulated assessments and summarized the evaluations