IDENTIFYING THE IMPACT OF SOCIOECONOMIC STATUS ON THE SLEEP QUALITY OF AGING ADULTS WITH MCI: A COMPARATIVE STUDY

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IDENTIFYING THE IMPACT OF SOCIOECONOMIC STATUS ON THE SLEEP QUALITY OF AGING ADULTS WITH MCI: A COMPARATIVE STUDY

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This thesis is dedicated to my family who supported me throughout my education.

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LIST OF SYMBOLS AND ABBREVIATIONS

AA	African American
AECO	Architecture, Engineering, Construction, and Operation
CDC	Centers for Disease Control and Prevention
ISI	Insomnia Severity Index
MCI	Mild Cognitive Impairment
MoCA	Montreal Cognitive Assessment
PSQI	Pittsburgh Sleep Quality Index
PSS	Perceived Stress Scale
REM	Rapid Eye Movement
SCD	Subjective Cognitive Decline

SUMMARY

Aging adults with mild cognitive impairment (MCI) are underrepresented in built environment research, specifically studies that mainly focus on low socioeconomic status and racial minorities. Part of this thesis is a part of a larger study conducted by the Cognitive Empowerment Program that is investigating the built environment of aging adults with MCI. The aim of this thesis is multifold: first, to provide a clearer understanding of the differences in the sleep environment related to socioeconomic status in aging adults with MCI and investigate if these differences affect their sleep health. Second, this thesis also aimed to evaluate which home environment factors, such as lighting, noise, temperature, air quality and housing insecurity affect sleep health for aging adults with MCI. Lastly, this thesis aimed to empower underprivileged aging adults with MCI and give back to this community that is not represented enough in research.

Affluent and underprivileged aging adults with MCI were surveyed in Atlanta Georgia, using mental health measures, cognitive health measures, sleep quality measures and a built environment survey that asks questions about their sleeping environment. This study was able to suggest an association between socioeconomic status with sleep quality, depression, and stress. The findings of this study also suggest a relationship between sleep health and the satisfaction with the current living arrangement, homeownership, wanting to move out of current living arrangement and moving frequency. Lastly, this study was also able to identify gender differences in sleep health.

This study is a preliminary investigation on the home and sleeping environments of underprivileged aging adults with MCI. Since there is a lack of literature about this

presented topic, future research should investigate the indoor environmental conditions and its relationship with sleep health of racial/ethnic minorities, low socioeconomic status groups, and cognitive aging adults to allow these vulnerable populations to age-in-place in their homes peacefully and independently.

CHAPTER 1. Introduction

1.1 Background

According to the US Census Bureau, those aged 65 and older have increased by 34.2% in the past decade in the United States (U.S. Census Bureau, 2020). The aging population is expected to continue to grow at a disproportionate rate. The U.S. Census Bureau predicts that, by 2040, 1 out of 5 Americans will be over age 65. Given aging is a major factor in cognitive impairment, it can be expected that the number of older adults suffering from some level of cognitive impairment will also increase. According to the Centers for Disease Control and Prevention (CDC, 2019), the prevalence of subjective cognitive decline (SCD) – self-reported experience of a decline in cognitive functioning such as confusion and memory loss – is 11.1% or 1 in 9 adults 45 and older, among aging adults 65 and older is 11.7%, compared to 10.8% among adults aged 45-64.

Mild cognitive impairment (MCI) is a syndrome that is characterized by cognitive decline that is greater than would be expected for an individual's age and educational level, but that does not significantly affect daily activities (Gauthier et al., 2006). Thus, it differs from dementia, which is characterized by more severe and pervasive cognitive abnormalities that significantly impair everyday functioning (Gauthier et al., 2006). According to the Alzheimer's Association, 12% to 18% of people aged 60 or older are living with MCI and 42 percent of Americans say they worry about developing MCI(Alzheimer's Association, 2022).

Sleep is an essential human need, particularly for aging adults. Inadequate sleep is associated with increased risk of obesity (Beccuti & Pannain, 2011; Buxton & Marcelli,

2010; Ogilvie & Patel, 2017; Reither et al., 2014), daytime fatigue (Elmenhorst et al., 2008), and deterioration in cognitive performance (Killgore, 2010; Willette-Murphy et al., 2006). Sleep deficiencies and disturbances can lead to negative physical and mental health outcomes, such as cardiovascular diseases (Suzuki et al., 2009), dementia (Shi et al., 2018), and a poorer quality of life (Lee et al., 2009). Sleep patterns and architecture also change with aging, causing numerous sleep problems for aging adults (Muehlroth & Werkle-Bergner, 2020; Ohayon et al., 2004). In one particular study, nearly half of the aging participants reported chronic sleep-related complaints, and 10%–20% reported difficulty initiating sleep (Keigo Saeki et al., 2015). Insomnia, parasomnia, and sleep schedule abnormalities, such as waking too early and difficulty falling asleep, are examples of sleep disorders in aging adults (Ancoli-Israel, 2005). Other causes of sleep disturbances include primary sleep disorders, circadian rhythm disturbances, medical and psychiatric conditions, medications, and dementia (Martin & Ancoli-Israel, 2008).

Research mostly looked at nocturnal bedroom conditions for the general population without considering age variations. However, physiological, and cognitive decline in aging adults may necessitate different environmental settings to attain optimal sleep quality. Aging, for example, can affect vision, particularly spatial contrast sensitivity, vision in low light, temporal sensitivity and motion perception, and visual processing speed (Owsley, 2011). Aside from vision-related sensitivity, light exposure levels required for circadian synchronization vary with age, with 75-year-olds requiring three times the amount of lighting exposure required for a 45-year-old to elicit the same circadian response due to changes in the eye associated with aging (Turner & Mainster, 2008). Aging-related hearing loss also causes enhanced neural responses to sounds and noise in aging adults compared

to younger populations (Herrmann et al., 2018). Aging is also linked to a gradual decrease in the perception of warmth versus cold (Guergova & Dufour, 2011).

Associations between socioeconomic status and poor sleep quality have been well documented in literature (Grandner et al., 2015; Grandner et al., 2010). Low income and low education level have been linked to poor sleep quality and insomnia (Gellis et al., 2005). A study reported that sleep quality plays a mediating role in translating socio-economic status into mental and physical well-being, and income levels mediate the effect of education on sleep and, in turn, health (Moore et al., 2002). However, as noted by a narrative review on sleep health for aging adults, research and the current literature does not particularly explore the relationship between socioeconomic status and sleep health for aging populations, especially aging adults with cognitive decline (Yang et al., 2022).

1.2 Research Goal, Key Research Question Hypothesis

Since aging adults with MCI are underrepresented in built environment research especially studies that mainly focus on low socioeconomic status and racial minorities, the **goal** of this research project is multifold. First, it aims to provide a clearer understanding of the differences in the sleep environment related to socioeconomic status in aging adults with MCI and if these differences in fact affects their sleep health. Second, this research aims to evaluate which home environment factors, such as lighting, noise, temperature, air quality and housing insecurity affect sleep health for aging adults with MCI. Lasty, this study aims to give back to the underprivileged participants by empowering them with knowledge and future actions, such as a list of common indoor environment issues affecting sleep and suggestions for inexpensive solutions (if applicable).

The **key research question** for this study is: *Do differences in the sleep environment related to socioeconomic status impact the quality of sleep for aging adults with MCI?* Since underprivileged aging adults with MCI live in unstable housing conditions that affect their access to optimum sleeping environments. It is hypothesized that these conditions, in turn, may negatively affect their sleep health compared to affluent aging adults with MCI.

1.3 Scope

The study presented in this thesis is limited in scope to:

1. Aging adults aged 55 and older and diagnosed with MCI. The study is also limited to aging adults without any major physical health conditions or recent surgeries and aging adults who live at their home independently.
2. While many levels of the built environment can affect sleep health, such as: neighborhood level, city level...etc., this study is only investigating the differences related to the home environment.
3. Since climate zones can affect the home environments of participants, this study is limited to Atlanta, Georgia which has a humid subtropical climate where the temperature typically varies from 35°F to 89°F and is rarely below 22°F or above 95°F.

1.4 Target Audience

The primary audience for this thesis is the architecture, engineering, construction, and operation (AECO) industry, facility managers and researchers to understand the sleeping environments for aging adults with MCI. This study can be a foundation to promote better sleeping environments and sleep health for such vulnerable population.

1.5 Thesis Outline

This thesis describes in detail the effect of socioeconomic status on sleeping environments and sleep health. The target population for this study is aging adults with MCI. Research background, research goals, key research question and the scope of this study are presented in chapter 1.

Chapter 2 presents a literature review regarding the relationship between the built environment and the sleep health of aging adults. The relationship is investigated only within the level of the home environment.

Chapter 3 proposes a sleep ecology map based on the literature reviewed for this study. The map allows for a better understanding of the factors investigated in this study that influences sleep health for aging adults.

Chapter 4 points out the research methodology including the design of experiments and the recruitment of participants. Chapter 4 then explains the detailed description of the measures used for this study.

Chapter 5 presents the results for this study and the demographic characteristics of the participants. The results then compare the data for both underprivileged and affluent participants.

Chapter 6 delves into the meaning, importance and relevance of the results presented in chapter 5 and shows how it relates to the current literature.

Chapter 7 highlights the conclusions, key findings of the study and discusses limitations and future research recommendations.

CHAPTER 2. Literature Review

This chapter aims to develop a clear understanding of the relationship between the built environment and the sleep health of aging adults. While many levels of the environments are possible (home, neighborhood/community, city, etc.…), the relationship is investigated only within the level of the home environment. The relationship between socioeconomic status and sleep health was also investigated in this chapter, a. A summary table of the studies used for this literature review can be found in Appendix A.

2.1 Home Environment and Sleep Health

At the level of a home environment, we found four major factors that affect sleep health in the ambient environment: 1) lighting, 2) thermal comfort, 3) noise, 4) crowding and isolation**.**

2.1.1 Light in the Home Environment and Sleep Health

Light plays a key role for the human circadian system to function properly, which is the body's biological clock that regulates when to be active and when to rest. Poor light exposure can interrupt the 24-hour sleep cycle. (Mishima et al., 2001). According to one study, the amount of 24-hour illumination aging adults are exposed to is associated with shorter sleep latencies (r=0.29, P.001, two-tailed) and depressed moods (r=0.21, P=0.01, two-tailed) (Wallace-Guy et al., 2002). When aging adults are not exposed to enough daylight throughout the day, lighting interventions may be required.

A significant amount of blue-enriched white light in the morning to phase-advance the circadian clock (move the rhythm earlier in the day), moderate to high levels of neutral

white light throughout the day in order enhance sleep - wake cycle without phase-shifting impacts on aging adults' sleep patterns, and muted lighting (yellowish-white light) in the night to prevent phase-delay (move the rhythm later in the day) to the biological rhythms are the best lighting arrangements for circadian rhythm entrainment (Shishegar et al., 2021). After being exposed to roughly 2,500 Lux full spectrum light sessions, aging adults with Alzheimer's disease had substantially ($p<.05$) reduced the overall wake time during the night and improved sleep efficiency. (McCurry et al., 2011). Artificial light at night constrains the secretion of melatonin, a hormone involved in sleep regulation (Cajochen, 2007; Lewy et al., 1980). Measurement of the indoor illumination level at night for 857 aging adults reported that the highest quartile of light intensity (mean 9.7 lux) showed higher odds for insomnia (OR 1.61, 95% CI 1.05–2.45) and negatively affected subjective and objective sleep quality(Obayashi, Saeki, & Kurumatani, 2014).

Another study linked artificial lighting levels of 5 lux or higher at night to an increased risk of depression (Obayashi et al., 2018). Artificial light at night also lengthened bedtime (Okamoto-Mizuno & Tsuzuki, 2010; Tsuzuki et al., 2015), postponed subsequent sleep-onset latency by 17 minutes (Obayashi, Saeki, Iwamoto, et al., 2014), and delayed wake time after sleep onset (Tsuzuki et al., 2015). It was also discovered that aging adults who prefer to age in place and get support while on bed rest do not receive adequate lighting throughout the day. Based on the 3-day records of illuminance loggers, a study with 44 participants in Japan calculated the subjects' rest-activity cycle illumination ratio (Log10 the mean illuminance during activity time - Log10 mean illuminance while resting) for aging adults and found that the average illumination was 988 lux and the mean illuminance while indoors was only 201 lux (Ichimori et al., 2015).

2.1.2 Thermal Comfort in the Home Environment and Sleep Health

In elderly populations, ambient temperature is also an crucial element determining sleep quality (Yan et al., 2022). Low indoor temperatures have been correlated to extended sleep onset latency (K. Saeki et al., 2015). High temperatures have also been linked to poor sleep quality. A summer research project in Gunma, Japan, found that the bedroom temperature for participants was between 25°C and 28°C (77 to 82.4°F), and that aging people' sleep was substantially more disrupted than that of younger ones at this temperature range (Ohnaka et al., 1995). A study in Japan evaluated two sleep settings for elderly men: 26°C (78.8°F) with 50% relative humidity (RH) and 32°C (89.6°F) with 50% RH. The researchers discovered that a greater temperature of 32°C (89.6°F) increased wakefulness while suppressing rapid eye movement (REM) (Okamoto-Mizuno et al., 2004).

Another Japanese study of older men found that a temperature of 28°C (82.4°F) was associated with prolonged wake time after sleep initiation and poor sleep quality (Tsuzuki et al., 2015). Another study stated that when the external air temperature in China rose by 1°C (1.8°F) during the summer, sleep efficiency fell by 0.72% and REM sleep duration fell by 2.10 minutes (Yan et al., 2022). Despite these data, as well as others indicating that optimal temperature conditions change between young and aging adults, (Hashiguchi et al., 2004; Natsume et al., 1992), engineers and designers currently use ASHRAE Standard 55 and ISO 7730:2005 as thermal comfort guidelines, which are based on research of younger populations and believe that identical conditions apply to aging adults.

When given control over their environment, aging individuals, on the other hand, have been observed to be less exact in altering their temperature environment. This is because, when compared to younger individuals, they have lower sensory ability to determine the immediate need for extra warmth or cooling. It is hypothesized that the inability to distinguish temperature differences is linked to both cognitive and physical decline (Collins et al., 1981).

2.1.3 Noise in the Home Environment and Sleep Health

Noise has also been identified as one of the aspects that affect aging adults' sleep quality (Thichumpa et al., 2018). A study of 231 older African Americans (AA) examined the relationships between household environment and in-bed behaviors as well as sleep duration and sleep efficiency. The analysis revealed that one standard deviation increase in an unfavorable household environment, which include noise, was correlated with lower self-reported sleep duration (β = 13.9 min, 95% confidence interval: 26.1, 1.7) and actigraphy-based sleep efficiency (β = 0.7%, 1.4, 0.0) (Johnson et al., 2021). Most individuals awake or arouse during sleep when the noise intensity is between 40 and 80dB. This range, nevertheless, can be affected by individual attributes such as aging and noise sensitivities (Basner & McGuire, 2018).

The World Health Organization (WHO) standards for night noise, issued in 2009, recommend that the yearly average noise exposure at night not exceed 40dB. Exposure to sounds louder over 40dB may cause insomnia, sleep disturbance, and other medical conditions such as high blood pressure and heart attacks (World Health Organization. Regional Office for, 2009). Among the reported variables linked with self-reported short

duration of sleep for aging AAs was household noise (Johnson et al., 2021). Another analysis revealed that the bedrooms of aging adults with insomnia were not fully silent at night, and the researchers hypothesized that aging adults disregard or underestimate the implications of nocturnal noise (Desaulniers et al., 2018).

2.1.4 Household Crowding and Sleep Health

Large households and crowding may also contribute to sleep deprivation patterns (Grandner et al., 2015). The federal government defines household crowding based on the number of persons per room (Blake K, 2007). According to the American Crowding Index (ACI), crowding occurs if there is more than one person per room; severe crowding occurs if more than 1.5 persons occupy a room - where rooms exclude bathrooms, half-rooms, foyers, and porches. A study of 371 Latino adults residing in urban low-income dwellings in the United States revealed that household crowding, as defined by the ACI (the ratio of persons to rooms ≥1), was associated with a lower likelihood of getting long sleep (≥8.5h), compared to both average (6.5-8.5h) and short sleep duration (≤6.5h) (Chambers et al., 2016).

2.1.5 Isolation and Sleep Health

On the other end of the crowding spectrum, older adults are more likely to suffer poor health outcomes as a result of social isolation and loneliness (Shankar et al., 2017), especially aging adults living alone. Social isolation and loneliness have been correlated with investigations to poor sleep health in aging adults. A nationwide representative sample of 759 older individuals in the United States suggested that perceived social isolation was associated with more time in bed and decreased objective sleep quality (Benson et al.,

2021). Social isolation was linked with lower self-reported sleep quality (Yu et al., 2018). Loneliness also has been found to be associated with shorter self-reported sleep and insomnia symptoms (Benson et al., 2021).

2.2 Socioeconomic Status and Sleep Health

Housing insecurity is characterized by high prices for housing in relation to one's income, frequent relocation, and financial problems in paying rent. These difficulties generally cause considerable psychological stress and cognitive pressure, which seem to have a serious effect on the sleep health of aging adults, whose cognitive health is indeed deteriorating. Based on a research study involving 4,850 participants, non-homeowners, those without health insurance, and those who lacked food security were considerably more likely to experience extremely short sleep (<5h) than those with stable and comfortable conditions (Whinnery et al., 2014). Another study, involving 159,856 respondents across 36 different states in the United States, correlated low income to regular insufficient sleep. (Grandner et al., 2010). Participants who struggled to pay rent or mortgage payments because of financial resource shortages slept 22 minutes less per night and had lesser sleep quality; and furthermore, participants who were evicted due to their inability to make rent/mortgage payments slept 32 minutes less than those who had decent housing circumstances (Bozick et al., 2021).

CHAPTER 3. Proposed Sleep Ecology Map

A map of sleep ecology is proposed based on the literature review done for this thesis. This sleep map is developed based on Bronfenbrenner's ecological systems theory (Bronfenbrenner, 1979) and the National Institute on Minority Health and Health Disparities research framework (Mujuru et al., 2022).

Figure 1 shows the sleep ecology map based on the literature reviewed. Ecological models seek to provide better understanding to complex patterns of causation where individual differences and environmental factors influence relationships. As illustrated in Figure 1, both individual differences and home environments are correlated to sleep health. Individual differences such as: physical health, mental health, physical activity, education, housing security, socioeconomic status, race/ethnicity, sex/gender differences, age and income have been associated with sleep health.

Home environment factors are considered as: noise, lighting, temperature, air quality, humidity, crowding and perceived safety have been linked to influence sleep health. The relationship between sleep health and physical, mental, and cognitive health is illustrated in Figure 1 as bidirectional. As identified from the literature, poor sleep can lead to multiple physical health problems such as: obesity and cardiovascular diseases. Some medical conditions can also lead to poor sleep health (CDC, 2022). Inadequate sleep is also proven to influence mental health such as anxiety, stress and depression. On the other hand, mental health problem such as anxiety can also lead to sleep disturbance (Staner., 2003). Further relationship between cognitive health and sleep is illustrated as bi-directional as

poor sleep can lead to cognitive decline and it is also identified from the literature that short sleep duration is associated with dementia (Sabia et al., 2021).

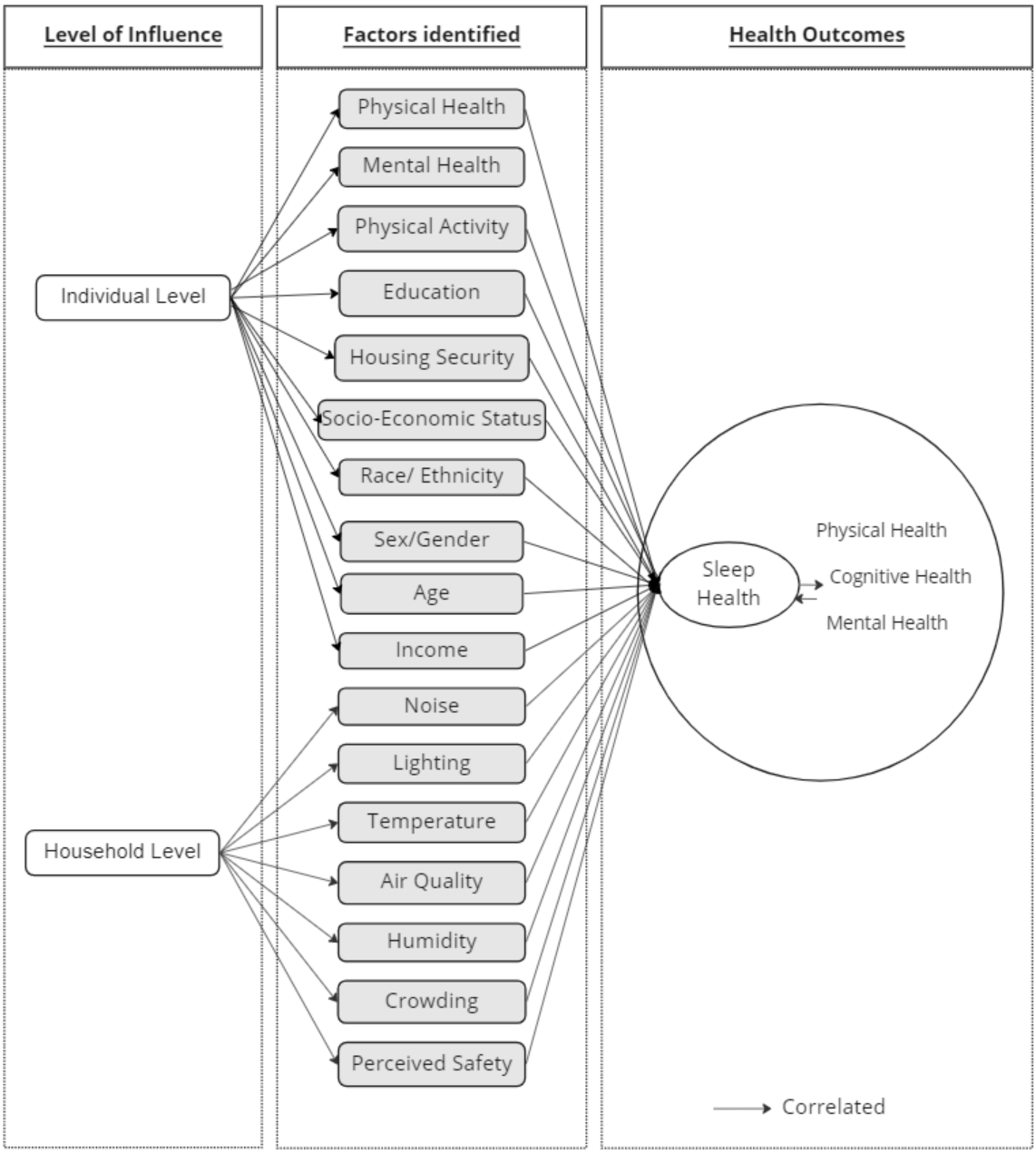


Figure 1 Sleep ecology map based on the reviewed literature

CHAPTER 4. Research Methodology

This chapters describes the research methodology including the design of experiments and the recruitment of participants. The detailed description of the measures used for this study, the questionnaire development and the statistical analysis will be explained.

4.1 Research Design

This study was conducted in three phases. The first phase was surveying the underprivileged aging adults with MCI about their sleeping environments and other validated measures. The second phase was surveying a group of affluent aging adults with MCI in an identical way. Lastly, the two sets of data were compared to identify the impact of socio-economic status and their sleep environment on sleep health for aging adults with MCI.

4.1.1 Recruitment of participants

Participants were recruited from two locations. The first recruitment location was a large urban public teaching hospital in metro Atlanta where 75% of patients are African American (AA), 42% are uninsured, and 24% are receiving Medicaid. It was expected to recruit 50 participants from location one but only 19 aging adults with MCI were recruited. The second recruitment location was through an innovative program jointly conducted by Georgia Institute of Technology and Emory Brain Health through the generosity of the James M. Cox Foundation, which is designed to empower individuals with MCI in metro

Atlanta. It was expected to recruit 20 participants but only 15 participants agreed to participate in this part of the study.

Participants were given the option to answer the survey in person by themselves or with help of a student and some participants answered the survey over the phone. The underprivileged community members surveyed were specifically recruited for this research project, and they were compensated for their time, whereas the affluent group were volunteers that are involved with a larger research program and compensation was not permitted.

4.1.2 Surveys

The survey for this study was developed using validated measures and a sleeping environment perception survey that was specifically created for this study. The validated measures consisted of sleep disturbance measures (such as the Pittsburgh Sleep Quality Index and the Insomnia Severity Index), mental health measures (such as Perceived Stress Scale, General Anxiety Disorder-7, and The Center for Epidemiological Studies-Depression) and cognitive functioning (such as The Montreal Cognitive Assessment).

4.1.3 Sleep Disturbance Measures

The Pittsburgh Sleep Quality Index (PSQI) (Buysse et al., 1989) is the most widely used measure for evaluating subjective sleep quality over the period of a month. Nineteen individual items generate seven "component" scores: subjective sleep quality, sleep latency, sleep duration, habitual sleep efficiency, sleep disturbances, use of sleeping medication, and daytime dysfunction. The sum of scores for these seven components yields

one global score. Each question is scored 0 (no difficulty) to 3 (severe difficulty). The survey asks questions such as; “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 spend in bed)?”, “During the past month, how often have you taken medicine (prescribed or ‘over the counter’) to help you sleep?”, and “During the past month, how often have you had trouble staying awake while driving, eating meals, or engaging in a social activity?”. The global scores range from 0 to 21. A higher total score (referred to as global score) indicates worse sleep quality and a score >5 is considered to identify a significant sleep disturbance. The complete survey can be found in Appendix C.

The Insomnia Severity Index (ISI) (Bastien et al., 2001) is a seven-item self-reported instrument that assess the severity of insomnia during both nighttime and daytime over the past month. The components evaluated are severity of sleep onset, sleep maintenance, early morning awakening problems, sleep dissatisfaction, interference of sleep difficulties with daytime functioning, noticeability of sleep problems by others, and distress caused by the sleep difficulties. A five-point Likert scale is used to score each item (e.g., 0 = no problem; 4 = very severe problem), yielding a total score ranging from a minimum of 0 points to a maximum of 28 points. The total score is interpreted as follows: absence of insomnia (0–7); sub-threshold insomnia (8–14); moderate insomnia (15–21); and severe insomnia (22–28). The complete survey can be found in Appendix D.

4.1.4 Mental Health Measures

The Perceived Stress Scale (PSS) (Cohen et al., 1983) is a widely used psychological instrument for measuring the perception of stress. PSS is a ten-item self-reported instrument that asks about feelings and thoughts during the last month. A five-

point Likert scale is used to score each item (e.g., 0 = never; 4 = very often), yielding a total score ranging between 0 to 40 points. Total scores ranging from 0-13 are considered low stress. Scores in the range of 14-26 are considered moderate perceived stress. Scores in the range of 27-40 are considered high perceived stress. The complete survey can be found in Appendix E.

The General Anxiety Disorder-7 (GAD-7) (Spitzer et al., 2006) is a seven-item self-reported anxiety scale that measures the severity of anxiety over the previous two weeks. A four-point Likert scale is used to score each item (e.g., 0 = not at all; 3 = nearly every day) yielding to a total score ranging between 0 to 21 points. The total score is interpreted as follows: total score 0-4 indicates minimal anxiety, a total score 5-9 indicates mild anxiety, a total score 10-14 indicates moderate anxiety, and a total score greater than 15 indicates severe anxiety. The complete survey can be found in Appendix F.

The Center for Epidemiological Studies-Depression (CES-D) (Radloff, 1977) is a twenty-item tool that asks participants to rate how often over the past week they experienced symptoms associated with depression, such as not talking as much as usual, poor appetite, and feeling lonely. Response options range from 0 to 3 for each item (0 = rarely or none of the time, 1 = some or little of the time, 2 = moderately or much of the time, 3 = most or almost all the time). Total score ranges from 0 to 60, with high scores indicating greater depressive symptoms. The complete survey can be found in Appendix G.

4.1.5 Cognitive Functioning

The Montreal Cognitive Assessment (MoCA) is a 10-minute cognitive screening tool with high sensitivity and specificity for detecting MCI (Nasreddine et al., 2005). The

30-point test is administered in 10 minutes and the higher the scores the better cognition. There are 12 items for cognitive domains; memory is assessed by a short-term memory recall task (5 points); visuospatial ability is assessed using a clock-drawing test (3 points) and a 3-dimensional cube copy (1 point); executive function is assessed using Trail Making B task (1 point), a phonemic fluency task (1 point), and a 2-item verbal abstraction task (2 points); attention, concentration, and working memory is tested using a sustained attention task (1 point), a serial subtraction task (3 points), and digits forward and backward tasks (1 point each); language is tested using a 3-item confrontation naming task with low-familiarity animals (lion, camel, rhinoceros; 3 points) and repetition of 2 syntactically complex sentences (2 points); orientation in time and place is also evaluated (6 points). The complete survey can be found in Appendix H.

4.1.6 Sleeping Environment and Socioeconomic status

In addition to the validated surveys, the researchers of this study developed a built environment survey that asks participants about their satisfaction with their sleeping environment. The complete survey can be found in Appendix I. The survey investigates thermal comfort, lighting, noise, air quality and the comfort of their bedroom furnishings. The survey includes questions such as “How satisfied are you with the temperature in your bedroom during your sleep?”, “How satisfied are you with the air quality in your bedroom during your sleep (i.e., stuffy/stale air, cleanliness, odours)?”, and “ How satisfied are you with the visual comfort of the lighting (i.e., reflections, contrast) when you go to bed or are going back to bed (i.e., night trips to the bathroom)?” Participants are asked to rate their satisfaction using a six-point scale that encourages participants to consider the question more cautiously and make a choice that either leans positively or negatively.

Participants were asked about socioeconomic variables such as income, education, access to insurance, and home ownership. Self-reported annual income levels were classified as follows: less than $25,000, $25,000-$50,000, $50,000-$100,000, and more than $100,000. Education level was categorized as < high school, some high school, high school graduate (including GED), trade school, college graduate, master's degree, and doctorate. Housing situation was classified as homeowner, renter, living with others but not paying rent or mortgage, and living with others and assisting with paying rent or mortgage. This part of the survey can be found in Appendix I.

4.2 Statistical Analysis

Descriptive statistics such as frequency and percentage were used to describe sample demographics and characteristics. The survey data were scored for data analysis. The validated measures were scored based on the scoring guide for each measure. Questions about the satisfaction with the sleeping environment were also scored, scores for each question ranged from 1 to 6 with very satisfied scored as 1 and very dissatisfied scored as 6. T-test method was performed to compare the data for the two socioeconomic groups to identify differences potentially related to socioeconomic status. Further, correlation analysis was conducted to measure the strength and the direction of the relationship between socioeconomic status and sleep quality variables, home environment variables, mental health variables and cognitive health variables. Statistical significance was set at $p < 0.05$ which indicated strong evidence against the null hypothesis.

CHAPTER 5. Results

5.1 Demographics

Tables 1 and 2 present the characteristics of the participants. Most of the underprivileged population were females and most of the affluent group composed of males. All the underprivileged participants were African American, while 11 out of 15 (73 %) affluent participants were white. The mean age for the underprivileged participants and the affluent participants were 68 ± 10 and 77 ± 4 respectively. Both the annual household income and education level were notably higher in the affluent participants. Most of the affluent participants were making more than $100,000 annually compared to less than $25,000 annually made by the majority of the underprivileged.

Forty-seven percent of the affluent participants had a college degree and 46% were either a master's degree holder or a Ph. D degree holder, in the underprivileged group most (53%) completed high school only. Most of the participants were either unemployed or retired in both socio-economic groups. All participants from the underprivileged group relied heavily on public assistance such as food stamps and federal/ state insurance care plans such as Medicaid.

Table 3 shows a detailed description of the participants homes. Most of both groups reported living in a single-family home. All the affluent participants live in homes greater than 1000 ft2 and most of the underprivileged group (74%) did not know the size of their homes. Fifty-two percent of the underprivileged group live in homes with 2 or 1 bedroom compared to the affluent group who live in homes with 3 or more bedrooms. There was no

presence of household crowding in either group. Seventy-four percent of the underprivileged were renters while the affluent group mostly owned their homes.

Table 1: Characteristics of the underprivileged group

Demographic Variable	**n (19)**	**%**
Gender		
Female	14	74%
Male	5	26%
Race		
African American	19	100%
Age		
55-60	4	21%
60-69	7	37%
70-79	5	26%
80+	3	16%
Annual household income		
Less than $25,000	15	79%
$25,000 - $50,000	4	21%
Education		
Some High School	2	11%
High School	10	53%
Trade School	2	11%
Bachelor's Degree	3	16%
Master's Degree	2	11%

Table 2 : Characteristics of the affluent group

Demographic Variable	n (15)	%
Gender		
Female	5	33%
Male	10	67%
Race		
White	11	73%
African American	3	20%
other	1	7%
Age		
60-69	1	7%
70-79	12	80%
80+	2	13%
Annual household income		
$50,000 - $100,000	7	47%
More than $100,000	8	53%
Education		
High School	1	7%
College graduate	7	47%
Master's degree	5	33%
Doctorate	2	13%

Table 3: Detailed Description of Participants Homes

	Underprivileged group	Affluent group
Number of bedrooms		
1	26%	7%
2	26%	14%
3	37%	50%
4+	11%	29%
Number of bathrooms		
1	37%	13%
2	53%	33%
3	5%	13%
4+	5%	40%
Size of the home		
< 1000 ft^2	5%	0%
1000-2000 ft^2	21%	40%
2001-3000 ft^2	-	7%
> 3000 ft^2	-	33%
Unknown	74%	20%
Adults live in the household		
1	58%	20%
2	32%	60%
3	11%	13%
4	0%	0%
5	0%	7%
Wanting to move from the current residence		
Yes	68%	0%
No	32%	100%
Type of housing		
Single-Family Home	58%	87%
Townhouse	5%	7%
Apartment	26%	7%
Assisted Living	11%	0%
Homeownership		
Homeowner	16%	87%
Renter	74%	13%
Living with others but not paying rent or mortgage	5%	-
Living with others and assisting with paying rent or mortgage	5%	-

5.2 Sleep quality

Table 4 shows the descriptive statistics of the PSQI scores. The mean PSQI score for the underprivileged group was significantly higher, with P(T<=t) one-tail = 0.03 assuming unequal variance, indicating a poorer sleep quality. In addition, participants from the underprivileged group that where living alone reported significantly higher PSQI score, indicating poorer sleep quality, than participants from the underprivileged group that lived with 1 or more adults in the household. Table 5 shows the results of the t-Test between the two group's PSQI score.

Table 4 Descriptive statistics of total PSQI scores

	Underprivileged group	**Affluent group**
Mean	9.06	6.13
Standard Error	1.10	0.94
Median	8	7
Mode	8	2
Standard Deviation	4.65	3.62
Coefficient of Variation	0.51	0.59
Range	15	12
Minimum	2	1
Maximum	17	13
Confidence Level (95.0%)	2.31	2.01

Table 5 : t-Test: Two-Sample Assuming Unequal Variances for PSQI scores

	Underprivileged group	Affluent group
Variance	21.58	13.12
Observations	19	15
Hypothesized Mean Difference	0.00	
df	31.00	
t Stat	2.03	
P(T<=t) one-tail	0.03	
t Critical one-tail	1.70	
P(T<=t) two-tail	0.05	
t Critical two-tail	2.04	

	Underprivileged group	Affluent group
Variance	21.58	13.12
Observations	19	15
Hypothesized Mean Difference	0.00	
df	31.00	
t Stat	2.03	
P(T<=t) one-tail	0.03	
t Critical one-tail	1.70	
P(T<=t) two-tail	0.05	
t Critical two-tail	2.04	

The mean PSQI score for homeowners and renters, across the two groups, was 5.8 and 9.6 respectively. This suggests that being a renter, instead of a homeowner, was significantly associated with higher PSQI scores, which indicates a poorer sleep quality (P(T<=t) one-tail = 0.01 assuming unequal variance).

Sleep duration was also found to have a significant association with income and educational level, (P(T<=t) one-tail = 0.03 assuming unequal variance) and (P(T<=t) one-tail = 0.02 assuming unequal variance), respectively. Underprivileged group with lower educational levels and low income reported shorter sleep duration than affluent participants with higher educational levels and higher income.

As for insomnia scores, the mean insomnia score for the underprivileged group was 11.2 which indicated sub-threshold of insomnia and the affluent group was 6.7 which is interpreted, according to the ISI, as absence of insomnia. Even though the underprivileged group had significantly poorer sleep quality, there was not a statistical difference in insomnia scores between the two groups. Table 6 shows results of t-test to compare the two groups insomnia scores.

Table 6: t-Test: Two-Sample Assuming Unequal Variances for Insomnia scores

	Underprivileged group	Affluent group
Mean	11.2	6.7
Variance	89.3	50.8
Observations	19	15
Hypothesized Mean Difference	0	
df	32	
t Stat	1.57	
P(T<=t) one-tail	0.06	
t Critical one-tail	1.69	
P(T<=t) two-tail	0.13	
t Critical two-tail	2.04	

5.3 Sleep Quality and Cognitive Functioning

Table 7 shows the descriptive analysis of MoCA scores. The MoCA score is the tool that was chosen for the assessment of cognitive functioning. The mean MoCA score for the underprivileged group, and the affluent group was 18.82 and 20.27, respectively. Both groups are within the MCI range (18-25) according to the MoCA. When MoCA scores were analyzed with respect to income, there were no significant difference between the two income groups. Further, no relationship was found between the cognitive functioning and sleep quality.

Table 7 The descriptive analysis of the MoCA Scores

	MoCA scores	
	Underprivileged group	Affluent group
Mean	18.82	20.27
Min	13.00	14.00
Max	27.00	27.00
SD	4.38	3.13
COV	0.23	0.15

Note: 18-25 = mild cognitive impairment, 10-17= moderate cognitive impairment and less than 10= severe cognitive impairment.

5.4 Sleep Quality and Mental Health

Table 8, Table 9, Table 10 shows the descriptive statistics for anxiety scores, depression scores and stress scores respectively.

Table 8 Descriptive statistics for anxiety scores

Anxiety Scores[1]		
	Underprivileged group	*Affluent group*
Mean	3.11	1.79
Standard Error	0.86	0.68
Median	3.00	0.50
Mode	3.00	0.00
Standard Deviation	3.77	2.55
Range	13.00	7.00
Minimum	0.00	0.00
Maximum	13.00	7.00
Confidence Level (95.0%)	1.82	1.47

[1] score 0-4: minimal anxiety, score 5-9: mild anxiety, score 10-14: moderate anxiety and score greater than 15: severe anxiety.

Table 9 Descriptive statistics for depressions scores

Depression Scores[1]		
	Underprivileged group	*Affluent group*
Mean	17.65	10
Standard Error	2.55	1.57
Median	18.00	8
Mode	24.00	7
Standard Deviation	10.51	6.071
Range	32.00	22
Minimum	2.00	3
Maximum	34.00	25
Confidence Level (95.0%)	5.40	3.36

[1] score of 16 or higher is considered depressed.

Table 10 Descriptive statistics for stress scores

Stress Scores[1]		
	Underprivileged group	*Affluent group*
Mean	10.12	21.93
Standard Error	2.35	1.51
Median	8.00	23.00
Mode	0.00	18.00
Standard Deviation	9.70	5.85
Range	36.00	19.00
Minimum	0.00	12.00
Maximum	36.00	31.00
Confidence Level (95.0%)	4.99	3.24

[1] score 0-13: low stress, 14-26: moderate stress, 27:40: high perceived stress.

The mean anxiety score for both groups was within the minimal anxiety range (0-4) and there was no significant difference between the two groups. When analyzing the data with respect to income categories and sleep quality, no relationship was found between anxiety scores and income categories and sleep quality.

As for depression, the underprivileged group showed a wide range of depression scale scores and it was found that depression was significantly associated with being low income (P(T<=t) one-tail = 0.01) and poor sleep quality (P(T<=t) one-tail = 0.02). Fifty nine percent of the underprivileged group were depressed according to this measure, and only 13% of the affluent group were depressed. Table 11 shows the comparison between the two group's Depression scores.

Table 11: t-Test: Two-Sample Assuming Unequal Variances for Depression Scores

	Underprivileged group	**Affluent group**
Mean	17.65	10
Variance	110.37	36.86
Observations	17	15
Hypothesized Mean Difference	0	
df	26	
t Stat	2.56	
P(T<=t) one-tail	0.01	
t Critical one-tail	1.71	
P(T<=t) two-tail	0.02	
t Critical two-tail	2.06	

Sixty six percent of the affluent group had moderate stress. On the contrary, 65% of the underprivileged group had low stress. Being affluent was significantly associated with stress (P(T<=t) one-tail=0.0001). Table 12 shows t-test between the two group's stress scores.

Table 12: t-Test: Two-Sample Assuming Unequal Variances for Stress Scores

	Underprivileged group	**Affluent group**
Mean	10.12	21.93
Variance	94.11	34.21
Observations	17	15
Hypothesized Mean Difference	0	
df	27	
t Stat	-4.23	
P(T<=t) one-tail	0.0001	
t Critical one-tail	1.70	
P(T<=t) two-tail	0.0002	
t Critical two-tail	2.05	

5.5 Sleep Quality and Home Environment

When asked "How satisfied are you with the temperature in your bedroom during your sleep?" the majority of both the affluent group (73%) and the underprivileged group (69%) responded either that they are very satisfied or satisfied. Figure 2 shows the detailed responses about the satisfaction with the temperature.

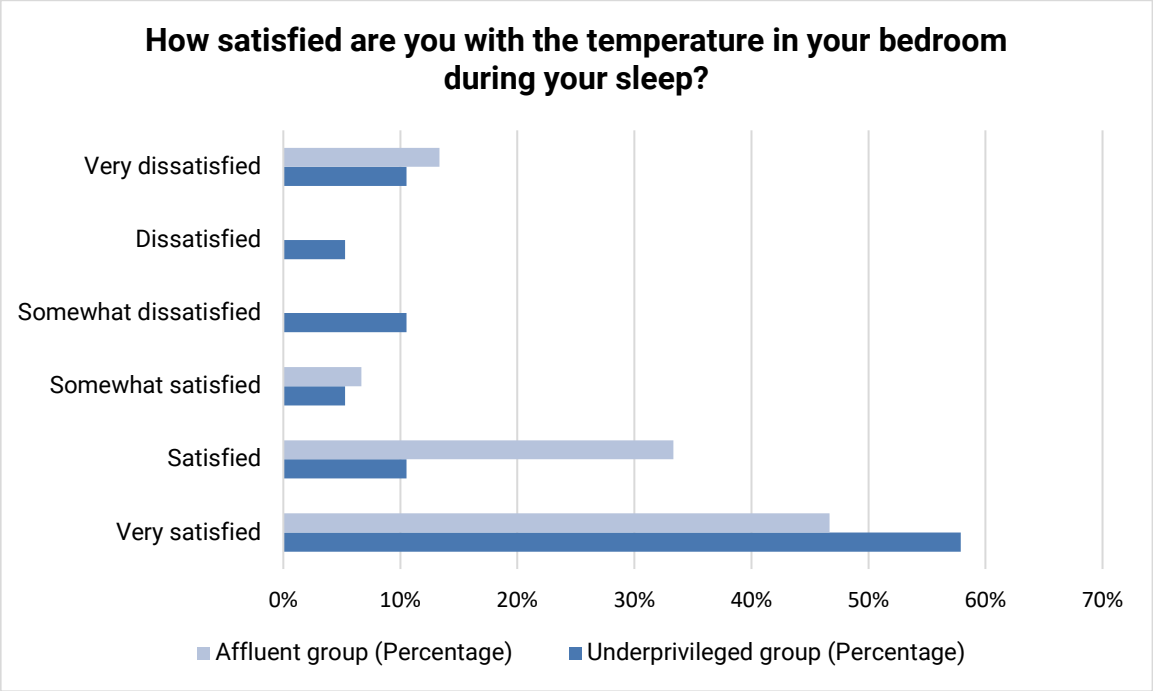


Figure 2 Satisfaction with the bedroom's temperature

When asked about the satisfaction with the air quality during sleep 93% of the affluent group reported either satisfied or very satisfied. Only 21% reported dissatisfaction with their air quality and there was no statistical difference between the two socioeconomic groups. No correlation or a relationship was found between air quality and sleep quality. Figure 3 shows the detailed response to the air quality question.

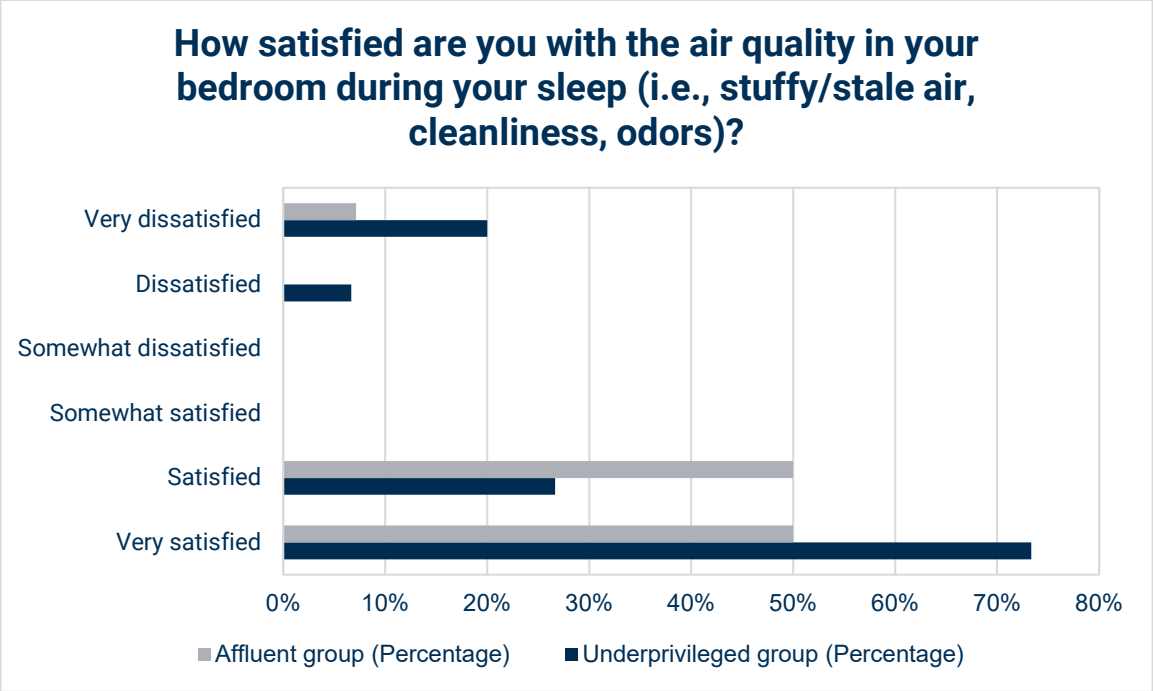


Figure 3 Satisfaction with the bedroom's air quality

When participants were asked, "How satisfied are you with the amount of light in your bedroom during your sleep?" most of both groups reported complete satisfaction with their lighting. Figure 4 shows the detailed responses to the satisfaction with the amount of light question. When participants were asked if the blinds and curtains in the bedroom are so effective that at sunrise the room is so dark it's hard to tell that the sun came up, most of both socioeconomic groups responded false. No correlation or a relationship was found between lighting and sleep quality. In addition, no lighting differences related to socioeconomic status was found.

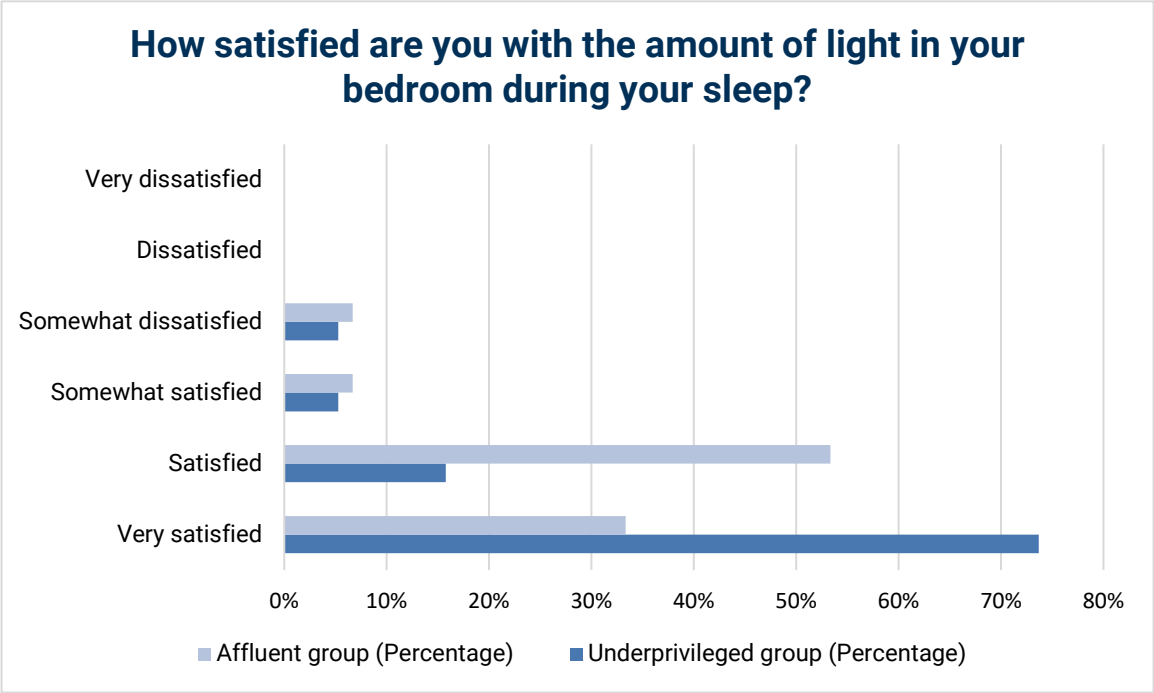


Figure 4 Satisfaction with the bedroom lighting

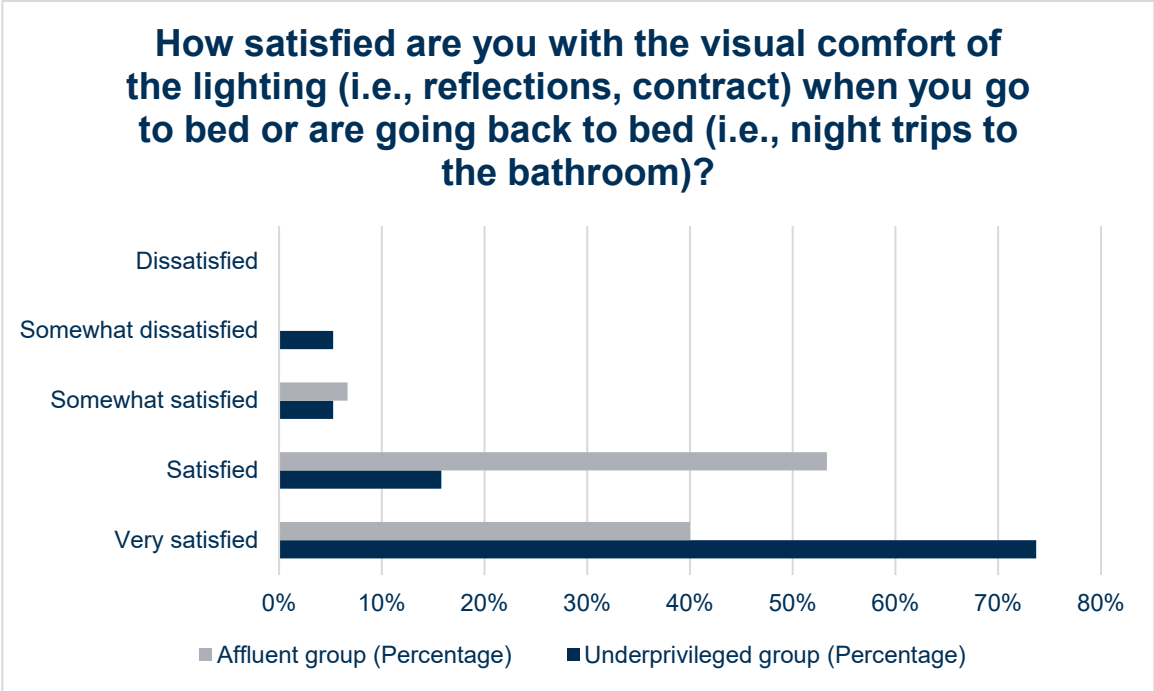


Figure 5 Satisfaction with the visual comfort of the lighting

As for noise in the sleeping environment, almost all participants from the two groups reported satisfaction with the noise level while they are sleeping. Only 10% of the underprivileged group reported loud neighbors and loud home appliances. On the other hand, when asked if noise from the radiators, floorboards, etc. is so minimal that they rarely are aware of such sounds, 63% of the underprivileged group and 60% of the affluent group reported false. Participants were asked about the satisfaction with the overall sleeping environment. Most of both groups reported that they are very satisfied with their sleeping environment. The detailed responses can be found in figure 7.

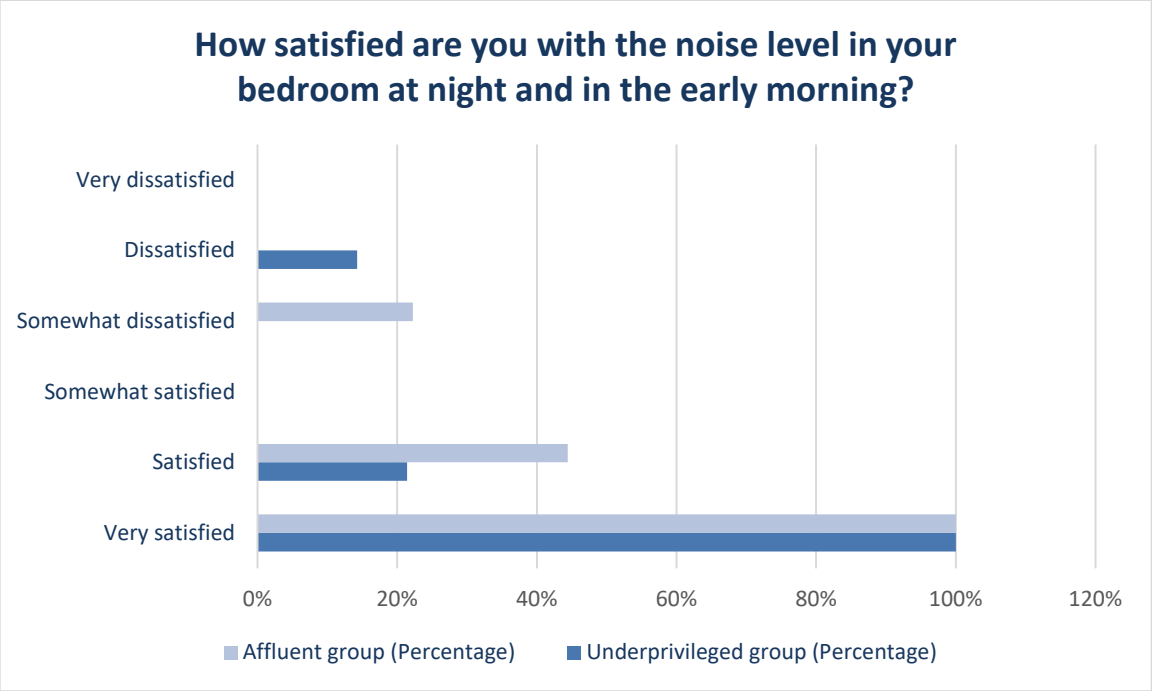


Figure 6 Satisfaction with the noise in the Sleeping environment

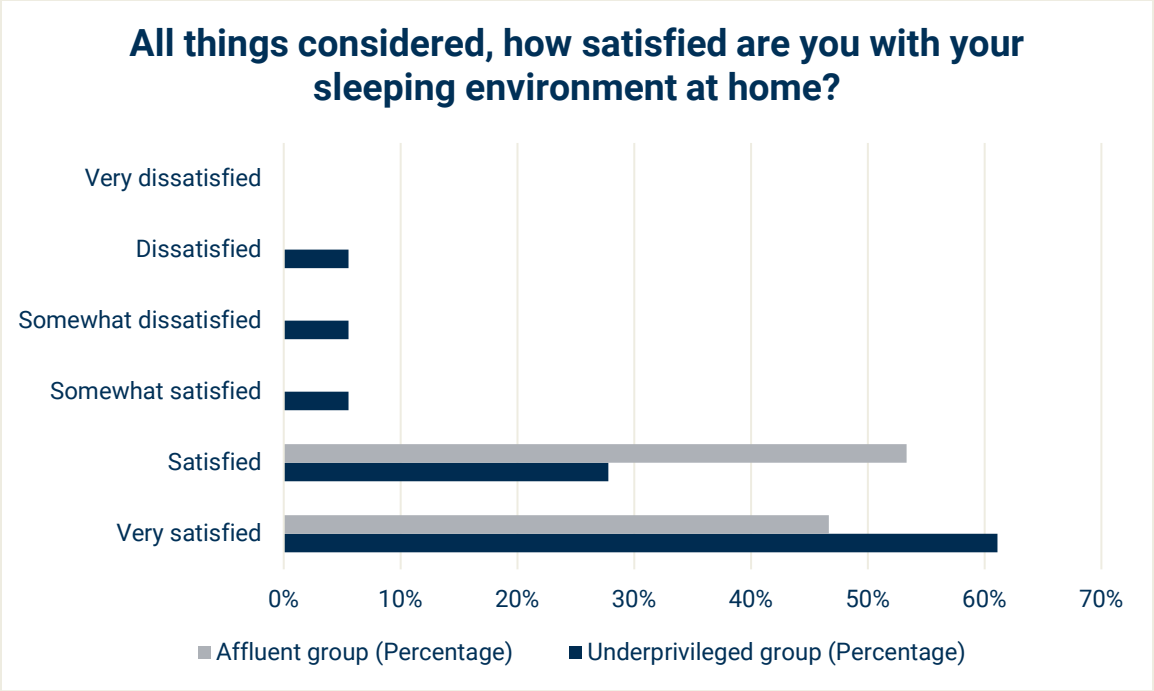


Figure 7 Overall satisfaction with the sleeping environment

Participants were asked seven true or false questions about their sleeping environment. These questions were based on a survey by (The University of Pennsylvania School of Medicine). Table 13 shows the responses to these true/false questions. There was no significant difference between the two groups related to income nor sleep quality.

Table 13 Results of the sleeping environment true/false questions

	Underprivileged group		Affluent group	
	n	%	n	%
I keep the temperature in the bedroom so cold that I have 2 or more blankets on the bed to stay warm at night.				
False	16	84%	14	93%
True	3	16%	1	7%
The blinds and curtains in the bedroom are so effective that at sunrise the room is so dark it's hard to tell that the sun came up.				
False	12	63%	10	67%
True	6	32%	5	33%
I have spent real time and money making sure that my mattress and pillow are perfect for me.				
False	7	37%	5	33%
True	11	58%	10	67%
During the night, my bedroom is insulated so well that I rarely if ever hear outside noise from the road, neighbors, etc.				
False	13	68%	12	80%
True	6	32%	4	27%
House noise from the radiators, floorboards, etc. is so minimal that I am rarely aware of such sounds.				
False	12	63%	9	60%
True	7	37%	7	47%
On three or more nights per week, I engage in two or more of the following behaviors in the bedroom: watch TV, read, plan, worry, work, clean, or eat).				
False	13	68%	7	47%
True	6	32%	8	53%

There was a significant association between being underprivileged and wanting to move from the current living arrangement (P(T<=t) one-tail=0.000003). All the affluent participants reported complete satisfaction with their current living arrangement, Table 14 shows Chi-Square test for Wanting to Move between the two group's response to the yes or no question about wanting to move. When the underprivileged participants were asked

why they wanted to move, most responded that they wish to have a home they own, they wanted a bigger and newer home, or they are struggling to keep up with the rent.

Table 14 Chi-Square test for Wanting to Move

Observed (O)			
	Yes(want to move)	**No (do not want to move)**	Σ
Underprivileged group	13	6	19
Affluent group	0	15	15
Σ	13	21	34
Expected (E)			
	Yes(want to move)	**No (do not want to move)**	
Underprivileged group	7.26	11.74	
Affluent group	5.74	9.26	
$(O-E)^2/E$			
	Yes(want to move)	**No (do not want to move)**	
Underprivileged group	4.53	2.80	
Affluent group	5.74	3.55	
CHI-SQUARE	2E+01		
df	1		
p-value	5E-05		

When participants from both groups were asked “How many times did you move in the past five years?”, there was a significant association with being underprivileged and moving frequency. Table 15 shows a t test between the two group’s responses to moving in the past five years. Additionally, female participants were significantly more likely to report increased number of moving than male participants (P(T<=t) one-tail=0.02).

Table 15 t-Test: Two-Sample Assuming Unequal Variances for Moving Frequency in the Past Five Years

	Underprivileged group	**Affluent group**
Mean	1.21	0
Variance	0.18	0
Observations	19	15
Hypothesized Mean Difference	0	
df	18	
t Stat	12.60	
P(T<=t) one-tail	0.0000000001	
t Critical one-tail	1.73	
P(T<=t) two-tail	0.0000000002	
t Critical two-tail	2.10	

The results of the Pearson correlation coefficients resulted in six negative correlation and one positive correlation with the income variable. The results are shown in Table 16. A high negative correlation was found between moving frequency and income. Further, a positive correlation was found between stress and income.

Table 16 Correlations with the income variable over all participants combined

Variable	**Correlation coefficient**	**Significance**
PSQI total score	-0.32	0.05
Sleep duration	0.33	0.03
Depression	-0.30	0.01
Stress	0.63	0.0001
Satisfaction with current living arrangement	-0.37	0.01
Being a Renter or a Homeowner	-0.71	0.000002
Wanting to move out of current living arrangement	-0.70	0.000003
Moving frequency over the past 5 years	-0.89	1.1E-10

CHAPTER 6. Discussion

The results of this study highlight many of the challenges that the underprivileged aging adults with MCI face with respect to their home environments and sleep health. This study, to our knowledge, is the first to provide evidence that aging adults with a combination of low-income and MCI experience lower self-reported sleep quality than aging adults diagnosed with MCI who are financially secure. The exploration of sleep disparities due to housing insecurities for aging adults with low socioeconomic status is limited in literature, and studies that specifically investigates the MCI population is nearly absent. However, the result of this study is consistent with previous studies that associate lower socioeconomic status with higher rates of sleep complaint (Grandner et al., 2010).

This study, to our best knowledge, was also the first to associate homeownership with sleep health specifically for aging adults with MCI. As non-homeowners had significantly lower sleep quality than homeowners based on the PSQI. This can be supported by current studies that associate home ownership and sleep health. For example, when a study investigated the sleep health of 4,850 adults, the study reported that non-homeowners were significantly more likely to report very short sleep (<5h) indicating a poor sleep quality (Whinnery et al., 2014).

Educational level, alongside income level and being a renter, is yet another factor that was found to be associated with sleep health of aging adults with MCI based on this study. Participants that were not college graduates and have low-income level reported significantly shorter sleep duration than college graduates with higher income levels. This finding is also supported by the literature. As one study investigated the sleep health of

aging adults with MCI reported that years of education was significantly (r = - .234, P = .003) negatively associated with poor sleep quality based on PSQI scores (McKinnon et al., 2014). Another study that did not specifically investigate aging adults stated that people with less education and lower-income levels report very short sleep (<5 h) compared to college graduates with an annual income of more than $75,000 (OR=0.32, P=0.030) (Whinnery et al., 2014).

The findings of this study also suggest correlations between depression and sleep quality in aging adults with MCI. Depression scores were highly correlated with poor sleep quality. This is consistent with one study's finding that was able to find a strong link between depression and sleep quality for patients with MCI (McKinnon et al., 2014). This can also be supported by a study that investigated 157 aging adults and reported that depression was significantly contributing to sleep quality variance ($p<0.05$) (Park et al., 2013).

An unexpected outcome was the positive correlation between stress levels and income for aging adults with MCI. However, since this study was investigating perceived stress (subjective stress), this finding is benchmarked with others. Cole et al. (1986) investigated socioeconomic variable (income) with respect to subjective and objective stress by examining 10,350 adults. They reported that subjective stress was highest among individuals with the most income and lowest among those with the least income (Cole et al., 1986). One possible explanation is that high income improves individual's evaluation of life but not individual's emotional well-being as there is a diversity of contextual inputs that generate the perception of being stressed, other than financial concern, such as: social isolation and loneliness, neighborhood quality, health problems (e.g. chronic pain) , age

discrimination, and recent life events (e.g. losing a loved one) (Kahneman & Deaton, 2010).

This study's aim was to investigate the differences in sleeping environments related to socioeconomic status and investigate if any of the built-environment metrics such as heat, air quality, lighting levels, and noise affects the sleep health of aging adults with MCI. Surprisingly, this study found no correlations between the sleeping environment and sleep health as most of the underprivileged participants stated that they were satisfied with their home environments. This can be explained as this underprivileged community was significantly associated with mental health problems (such as depression), housing insecurity (such as increased moving frequency) and cognitive health problems (such as MCI) along with their unstable financials. These diverse problems may be more of a visible and a noticeable problem to this population that they believe it affects their daily life more than optimal home environments and building systems.

Another explanation for not finding correlation between income and home environments may be the limited sample size and how the surveys were administered to the participants. Since this population have severe financial problems, they did not have access to technology to take the survey privately from the comfort of using their own smart devices. Further, this population also did not feel comfortable to respond to the survey by themselves which may have affected the results of the survey.

CHAPTER 7. Conclusions

Aging adults with MCI are underrepresented in built environment research especially studies that mainly focus on low socioeconomic status and racial minorities. This study aimed to provide a clearer understanding of the differences in the sleep environment related to socioeconomic status in aging adults with MCI and investigate if these differences affect their sleep health. Sleep health of two socioeconomic groups were investigated: underprivileged aging adults with MCI and affluent aging adults with MCI. When participants were surveyed about their sleep health and factors that are known to influence sleep health including mental health, cognitive health, and the sleeping environment, this study was able to associate socioeconomic status with sleep quality, depression, and stress.

This thesis also aimed to evaluate which home environment factors, such as lighting, noise, temperature, air quality and housing insecurity affect sleep health for aging adults with MCI. While no relationship was found between environmental factor and sleep health for aging adults with MCI, this study found a relationship between sleep health and the satisfaction with the current living arrangement, homeownership, wanting to move out of current living arrangement and moving frequency. This study was also able to associate gender differences to sleep health.

Empowering underprivileged aging adults was the last aim for this thesis and this study was the one of the first studies dedicated to underprivileged aging adults with MCI. When surveying and recruiting participants, the researchers of this study explained to the participants how ethnic minorities and underprevligaed groups, especially with MCI, are

not represented enough in research studies. The researchers expressed to the participants that there is no right or wrong answer for this survey, the researchers emphasized that they only want this population's true perceptions to be represented in research studies.

Acknowledging the limitations, this study is prone to researcher bias and a few sampling issues. This study excluded participants with health complications that were thought to influence sleep health. Some of the excluded participants, unknowingly, could have been good for the study. Another limitation was also the sample size and not getting enough survey responses from both groups. The underprivileged participants were recruited during their appointment at the memory clinic, due to the length of the survey and their personal commitments after the appointments, recruiting participants was a challenge.

This study also suffered from time constraints that limited the methodology of the research. Participants were surveyed only during the summer month, if this study was a longitudinal research study and participants were surveyed all year long across different seasons, the participants perceptions about their sleeping environment and their satisfaction with their home environments might have changed.

This study is a preliminary investigation on the home environments of aging adults with MCI. There is a lack of literature about the indoor environmental conditions and its relationship with sleep health of racial/ethnic minorities, low socioeconomic status groups, and cognitive aging adults which future research should focus on. Future studies also should include objective measures (such as: home measurements) alongside subjective

measures to be able to thoroughly investigate the differences in home environments related to socioeconomic status, not only perceptions.

While this study mainly investigated underprivileged African Americans with MCI, future studies should investigate the sleep health of other racial/ethnic minorities. Finally, research should focus on understanding the expectations and needs of aging adults with cognitive aging to allow them to age in place in their homes peacefully and independently.

APPENDIX A. Summary of Home Environment and Sleep Health Literature

Table 17 Summary of Home Environment Literature

Article(s)	Environmental variable	Sleep measure	Sample Size	Method (Study origin, Male or/and Female)	Age	Health Condition	Key findings
				Home Environment			
(Tholking et al., 2020)	Light	PSQI	44 participants	At-home study with surveys (Netherlands, Male and Female)	≥65 years	Healthy	Use of automated LED strips from bed to bathroom fall prevention. Fear of falling (FOF) overnight. FOF declined from 5.5 ± 3.0 to 3.8 ± 3.2 ($p = 0.001$).
(K. Saeki et al., 2015)	Thermal Environment	A self-administered sleep diary and Actigraphic (Actiwatch 2)	861 participants	Indoor temperature measured at home (Japan, Male and Female)	≥60 years	Not specified	Indoor evening temperature showed a significant association with Sleep onset Latency ($\beta = -0.022$, $P < 0.01$)
(Obayashi, Saeki, Iwamoto, et al., 2014)	Light	PSQI and an actigraphy (Actiwatch 2)	857 participants	At home study with light sensors (Japan, Male and Female)	≥60 years	84 participants were diagnosed with insomnia	Light at Night (LAN) exposure in home settings was significantly associated with both subjectively and objectively measured sleep quality.
(Yan et al., 2022)	Thermal Environment	Sleep questionnaire, actigraph, and skin temperature data loggers.	45 participants	At Home study with surveys (China, male and Female)	> 65 years	Healthy	Sleep quality significantly decreased at high air temperature, relative humidity, and CO2 concentration.
(Youngstedt et al., 2004)	Light	Sleep questionnaire and actigraph	459 participants	At-home study for 5-7 days (United states, Female)	≥50 years	Postmenopausal women	Morning illumination was modestly linked to better sleep and less depressed mood.
(Ohnaka et al., 1995)	Thermal Environment	Recording body movement while sleeping and sleep questionnaire	20 participants	At-home study measuring temperature and humidity (Gunma, Male, and Female)	≥67, years	Healthy	The sleep of elderly was distributed easily by high air temperatures.

Table 2. (Continued)

Article(s)	Environmental variable	Sleep measure	Sample Size	Method (number of participants, Study origin, Male or/and Female)	Age	Health Condition	Key findings
(Sander et al., 2015)	Light	PSQI, the Morningness –Eveningness questionnaire and Actiwatch	29 participants	At home study (Denmark, Male and Female)	> 65 years	Healthy	No significant difference in total sleep for subjects receiving blue-enriched light or blue suppressed light.
(Obayashi, Saeki, Iwamoto, et al., 2014)	Light	Actigraph	192 participants	At home study measured 48 h of evening light exposure, portable light meter (Japan, Male, and Female)	≥60 years	Not specified	The median intensity of evening light exposure was 27.3 lux, and the median sleep-onset latency was 17 min. Exposure to evening light in a home setting prolongs subsequent sleep-onset latency in the elderly.
(Okamoto-Mizuno & Tsuzuki, 2010)	Thermal Environment	Sleep questionnaire and Actigraph	19 participants	At home study for 5 days in fall, winter and summer (Japan, Male and Female)	≥62 years	Healthy	Wakefulness and activity during sleep were significantly increased in summer compared with fall or winter, indicating disturbed sleep. Total sleep time and sleep efficiency index decreased in summer compared to fall and winter.
(Tsuzuki et al., 2015)	Thermal Environment and Light	Actigraphy, Sleep diary and questionnaire	8 participants	At home study for 5 days with temperature and humidity sensors (Japan, Male and Female)	≥60 years	Healthy	Increased temperature, humidity, and lighting level during the sleep period increased wake time after sleep onset and impaired the sleep quality.
(Wallace-Guy et al., 2002)	Light	Actigraph	154 participants	One-week continuous recording of illumination and sleep (United States, Female)	≥ 51 years	Not specified	Dim illumination in the 4 hours before bedtime (mean 24 lux) was not significantly related to sleep amount (in bed or out of bed) sleep efficiency, sleep latency, wake within sleep, or mood.
(Ichimori et al., 2015)	Light	PSQI	44 participants	Calculated the illuminance ratio per minute during activity while in bed (Japan, Male and Female)	≥ 64 years	In bed rest	Average illuminance during activity time was close to the 1000 lx mark (988 lx)

Table 2. (Continued)

Article(s)	Environmental variable	Sleep measure	Sample Size	Method (number of participants, Study origin, Male or/and Female)	Age	Health Condition	Key findings
(McCurry et al., 2011)	Light	Actigraph watch and Sleep Disorders Inventory	132 participants	Participants were randomly assigned to one of three active treatments (walking, light, combination treatment) or contact control. Participants received three or six in-home visits(United States, Male and Female)	Mean age: 81 years	Alzheimer Disease	Patients with greater adherence (4+ days/week) to walking 30 continuous mins/day and light exposure sessions of approximately 2,500 of full spectrum light had significantly ($p<.05$) less total wake time and better sleep efficiency at post-test than those with lesser adherence.
(Johnson et al., 2021)	Overall satisfaction with sleep environment	Sleep questionnaire and actigraph	231 participants	Survey that asks questions regarding safety, physical comfort, temperature, noise, and light disturbances (United States,Male and Female)	Mean age: 66.3 years	Not specified	An increase in an adverse household environment score was associated with lower sleep duration ($\beta = -13.9$ min, 95% confidence interval: -26.1, -1.7) and sleep efficiency ($\beta = -0.7\%$, -1.4, 0.0).
(Desaulniers et al., 2018)	Noise	Insomnia Severity Index	599 participants	Survey asks questions about household environment (Canada, Male and Female)	≥70 years	Insomnia	Over 40% of the study participants were using a pillow that was uncomfortable, and almost 30% said that their bedroom was not completely quiet.
(Shishegar et al., 2021)	Light	Actigraphy, PSQI , Patient-Reported Outcomes Measurement Information System Sleep Disturbance and Epworth Sleepiness Scale	21 participants	two lighting interventions in the living room for 9 days; 500 lux in the morning (8:00-12:00) gradually dimming throughout the day until reaches 100 lux after 20:00 (United States, Female)	≥65 years	Healthy and MCI	The whole-day lighting scheme with varying illuminance levels a constant Correlated Color Temperature (CCT) of 2700 k significantly increased the mean sleep duration at night by 19.52 min and a 5.12-min increase in mean sleep-onset latency.

Table 2. (Continued)

Article(s)	Environmental variable	Sleep measure	Sample Size	Method (number of participants, Study origin, Male or/and Female)	Age	Health Condition	Key findings
(Grandner et al., 2015)	Socioeconomic status	One item that asks about perceived insufficient rest or sleep from Behavioral Risk Factor Surveillance System	323,047 participants	Survey to assess the social and behavioral determinants of perceived insufficient sleep(United States, Male and Female)	≥ 18 years	Not specified	Low-income groups were associated with an increased level of insufficient sleep. Multiracial individuals were more likely to report insufficient sleep than other races.
(Chambers et al., 2016)	Household crowding and Neighborhood disorder	PSQI	371 participants	Survey to investigate living conditions that influence sleep of Latino residents(371, United States, Male and Female)	≥ 18 years	Not specified	Latino adults living in low-income housing in the United States found that household crowding was associated with low odds of long sleep duration (OR=0.41) relative to average (OR=0.96) and short sleep duration (OR=2.33)

APPENDIX B. Summary of Housing Insecurity and Sleep Health Literature

Table 18 Summary of Housing Insecurity and Sleep Health Literature

Housing Insecurity							
Article(s)	**Environmental variable**	**Sleep measure**	**Sample Size**	**Method (Study origin, Male or/and Female)**	**Age**	**Health Condition**	**Key findings**
(Whinnery et al., 2014)	Sociodemographic, and socioeconomic position	Sleep questions National Health and Nutrition Examinatio n Survey)	4,850 participants	Survey (United States, Male and Female)	≥ 18 years	Not specified	Non-homeowners, those without health insurance and food security were significantly more likely to report very short sleep (<5h)
(Grandner et al., 2010)	Sociodemographic, and socioeconomic position	Survey	159,856 participants	Sample representing 36 states from the Behavioral Risk Factor Surveillance System surveyed over the phone (United States, Male and Female)	Mean age: 51.5 years	Not specified	Unemployment more than a year(OR 2.22, 95% CI 1.76–2.80) <.0001 p-Value in female and (OR 2.97, 95% CI 1.83–4.82) <.0001 p-Value in male, low income $10,000-$15,000 (OR 1.84, 95% CI 1.55–2.18) <.0001 p-Value in female and (OR 1.88, 95% CI 1.41–2.52) <.0001 p-Value in male and socioeconomically disadvantaged have higher like hood of sleep complains
(Bozick et al., 2021)	Socioeconomic status	Survey	1046 participants	Survey asks questions about housing insecurity, sleep duration and sleep quality(United States, Male and Female)	Mean age: 31.2 years	Not specified	Participants who were unable to pay rent/mortgage payments slept an average of 22 fewer minutes at night and had lower sleep quality than those who can pay the payments. Participants who were evicted slept on average 32 fewer minutes than those who had stable housing conditions

APPENDIX C. The Pittsburgh Sleep Quality Index

Pittsburgh Sleep Quality Index (PSQI)

Instructions: The following questions relate to your usual sleep habits during the **past month only**. Your answers should indicate the most accurate reply for the majority of days and nights in the past month. **Please answer all questions.**

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

2. During the past month, how long (in minutes) has it usually taken you to fall asleep each night? ____

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

4. 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.) _____

5. During the past month, how often have you had trouble sleeping because you…	Not during the past month	Less than once a week	Once or twice a week	Three or more times a week
a. Cannot get to sleep within 30 minutes				
b. Wake up in the middle of the night or early morning				
c. Have to get up to use the bathroom				
d. Cannot breathe comfortably				
e. Cough or snore loudly				
f. Feel too cold				
g. Feel too hot				
h. Have bad dreams				
i. Have pain				
j. Other reason(s), please describe:				
6. During the past month, how often have you taken medicine to help you sleep (prescribed or "over the counter")?				
7. During the past month, how often have you had trouble staying awake while driving, eating meals, or engaging in social activity?				
	No problem at all	Only a very slight problem	Somewhat of a problem	A very big problem
8. During the past month, how much of a problem has it been for you to keep up enough enthusiasm to get things done?				
	Very good	Fairly good	Fairly bad	Very bad

	No bed partner or room mate	Partner/roommate in other room	Partner in same room but not same bed	Partner in same bed
10. Do you have a bed partner or roommate?				
	Not during the past month	Less than once a week	Once or twice a week	Three or more times a week
If you have a roommate or bed partner, ask him/her how often in the past month you have had:				
a. Loud snoring				
b. Long pauses between breaths while asleep				
c. Legs twitching or jerking while you sleep				
d. Episodes of disorientation or confusion during sleep				
e. Other restlessness while you sleep, please describe:				
9. During the past month, how would you rate your sleep quality overall?				

APPENDIX D. The Insomnia Severity Index (ISI)

Insomnia Severity Index

The Insomnia Severity Index has seven questions. The seven answers are added up to get a total score. When you have your total score, look at the 'Guidelines for Scoring/Interpretation' below to see where your sleep difficulty fits.

For each question, please CIRCLE the number that best describes your answer.

Please rate the CURRENT (i.e. LAST 2 WEEKS) SEVERITY of your insomnia problem(s).

Insomnia Problem	None	Mild	Moderate	Severe	Very Severe
1. Difficulty falling asleep	0	1	2	3	4
2. Difficulty staying asleep	0	1	2	3	4
3. Problems waking up too early	0	1	2	3	4

4. How SATISFIED/DISSATISFIED are you with your CURRENT sleep pattern?

Very Satisfied	Satisfied	Moderately Satisfied	Dissatisfied	Very Dissatisfied
0	1	2	3	4

5. How NOTICEABLE to others do you think your sleep problem is in terms of impairing the quality of your life?

Not at all Noticeable	A Little	Somewhat	Much	Very Much Noticeable
0	1	2	3	4

6. How WORRIED/DISTRESSED are you about your current sleep problem?

Not at all Noticeable	A Little	Somewhat	Much	Very Much Noticeable
0	1	2	3	4

7. To what extent do you consider your sleep problem to INTERFERE with your daily functioning (e.g., daytime fatigue, mood, ability to function at work/daily chores, concentration, memory, mood, etc.) CURRENTLY?

Not at all Interfering	A Little	Somewhat	Much	Very Much Interfering
0	1	2	3	4

APPENDIX E. Perceived Stress Scale

The Perceived Stress Scale (PSS)

A more precise measure of personal stress can be determined by using a variety of instruments that have been designed to help measure individual stress levels. The first of these is called the **Perceived Stress Scale**.

The Perceived Stress Scale (PSS) is a classic stress assessment instrument. The tool, while originally developed in 1983, remains a popular choice for helping us understand how different situations affect our feelings and our perceived stress. The questions in this scale ask about your feelings and thoughts during the last month. In each case, you will be asked to indicate how often you felt or thought a certain way. Although some of the questions are similar, there are differences between them and you should treat each one as a separate question. The best approach is to answer fairly quickly. That is, don't try to count up the number of times you felt a particular way; rather indicate the alternative that seems like a reasonable estimate.

For each question choose from the following alternatives:
0 - never 1 - almost never 2 - sometimes 3 - fairly often 4 - very often

_____ l. In the last month, how often have you been upset because of something that happened unexpectedly?

_____ 2. In the last month, how often have you felt that you were unable to control the important things in your life?

_____ 3. In the last month, how often have you felt nervous and stressed?

_____ 4. In the last month, how often have you felt confident about your ability to handle your personal problems?

_____ 5. In the last month, how often have you felt that things were going your way?

_____ 6. In the last month, how often have you found that you could not cope with all the things that you had to do?

_____ 7. In the last month, how often have you been able to control irritations in your life?

_____ 8. In the last month, how often have you felt that you were on top of things?

_____ 9. In the last month, how often have you been angered because of things that happened that were outside of your control?

_____ 10. In the last month, how often have you felt difficulties were piling up so high that you could not overcome them?

APPENDIX F. General Anxiety Disorder-7

General Anxiety Disorder-7

Over the last two weeks, how often have you been bothered by the following problems?	Not at all	Several days	More than half the days	Nearly every day
1. Feeling nervous, anxious, or on edge	0	1	2	3
2. Not being able to stop or control worrying	0	1	2	3
3. Worrying too much about different things	0	1	2	3
4. Trouble relaxing	0	1	2	3
5. Being so restless that it is hard to sit still	0	1	2	3
6. Becoming easily annoyed or irritable	0	1	2	3
7. Feeling afraid, as if something awful might happen	0	1	2	3

APPENDIX G. The Center for Epidemiological Studies-Depression

Center for Epidemiologic Studies Depression Scale

Below is a list of the ways you might have felt or behaved. Please tell me how often you have felt this way during the past week.

During the Past week				
	Rarely or none of the time (less than 1 day)	Some or a little of the time (1-2 days)	Occasionally or a moderate amount of time (3-4 days)	Most or all of the time (5-7 days)
1. I was bothered by things that usually don't bother me.				
2. I did not feel like eating; my appetite was poor.				
3. I felt that I could not shake off the blues even with help from my family or friends.				
4. I felt I was just as good as other people.				
5. I had trouble keeping my mind on what I was doing.				
6. I felt depressed.				
7. I felt that everything I did was an effort.				
8. I felt hopeful about the future.				
9. I thought my life had been a failure.				
10. I felt fearful.				
11. My sleep was restless.				

12. I was happy.				
13. I talked less than usual.				
14. I felt lonely.				
15. People were unfriendly.				
16. I enjoyed life.				
17. I had crying spells.				
18. I felt sad.				
19. I felt that people dislike me.				
20. I could not get "going."				

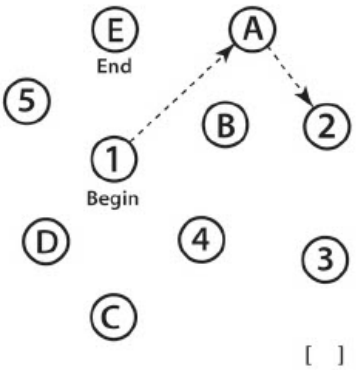
APPENDIX H. The Montreal Cognitive Assessment

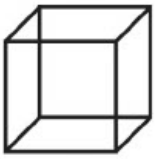
MONTREAL COGNITIVE ASSESSMENT (MOCA)

Version 7.1 Original Version

NAME :
Education :
Sex :
Date of birth :
DATE :

VISUOSPATIAL / EXECUTIVE





Copy cube

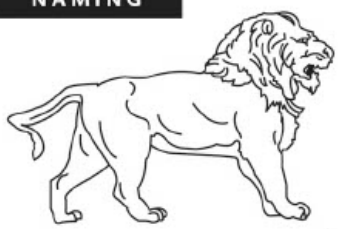
[ ] [ ]

Draw CLOCK (Ten past eleven)
(3 points)

[ ] Contour [ ] Numbers [ ] Hands

POINTS __/5

NAMING



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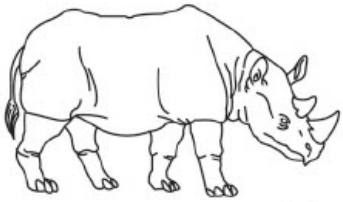

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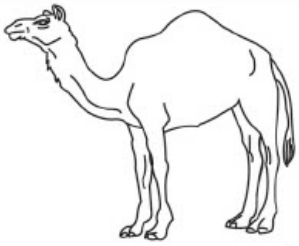

[ ]

__/3

MEMORY

Read list of words, subject must repeat them. Do 2 trials, even if 1st trial is successful. Do a recall after 5 minutes.

	FACE	VELVET	CHURCH	DAISY	RED
1st trial					
2nd trial					

No points

ATTENTION

Read list of digits (1 digit/ sec.).

Subject has to repeat them in the forward order [ ] 2 1 8 5 4

Subject has to repeat them in the backward order [ ] 7 4 2

__/2

Read list of letters. The subject must tap with his hand at each letter A. No points if ≥ 2 errors

[ ] F B A C M N A A J K L B A F A K D E A A A J A M O F A A B

__/1

Serial 7 subtraction starting at 100 [ ] 93 [ ] 86 [ ] 79 [ ] 72 [ ] 65

4 or 5 correct subtractions: **3 pts**, 2 or 3 correct: **2 pts**, 1 correct: **1 pt**, 0 correct: **0 pt**

__/3

LANGUAGE

Repeat : I only know that John is the one to help today. [ ]

The cat always hid under the couch when dogs were in the room. [ ]

__/2

Fluency / Name maximum number of words in one minute that begin with the letter F [ ] _____ (N ≥ 11 words)

__/1

ABSTRACTION

Similarity between e.g. banana - orange = fruit [ ] train – bicycle [ ] watch - ruler

__/2

DELAYED RECALL

	Has to recall words WITH NO CUE	FACE [ ]	VELVET [ ]	CHURCH [ ]	DAISY [ ]	RED [ ]	Points for UNCUED recall only
Optional	Category cue						
	Multiple choice cue						

__/5

ORIENTATION

[ ] Date [ ] Month [ ] Year [ ] Day [ ] Place [ ] City

__/6

www.mocatest.org

Normal ≥ 26 / 30

TOTAL __/30

Add 1 point if ≤ 12 yr edu

Administered by: _____

APPENDIX I. Sleeping Environment Survey

Type of Housing

In which type of housing do you currently live?

- Apartment
- Single-Family Home
- Townhouse
- Condominium
- Assisted Living
- Other? _____ (please specify)

What is the size of your home? _____sq ft.

How many bedrooms are in your home?

- One
- Two
- Three
- Four or more

How many bathrooms are in your home?

- One
- Two
- Three
- Four or more

Do you have any pets (dogs, cats, others)? _____, how many? _____

Do you share your bedroom with anyone else?

- No, I sleep by myself.
- Yes, I share my room with _____.

Which of the following best describes your current housing situation?

- Homeowner
- Renter
- Living with others but not paying rent or mortgage
- Living with others and assisting with paying rent or mortgage

Are you satisfied with your current living arrangements?

- Yes
- No, because _____

If not, please tell us why? (Check all that apply)

- Home/Apartment needs repairs that I cannot afford
- The landlord won't make repairs
- Property Value Fell
- Foreclosure Concerns
- Bad/Rude/Loud Neighbors
- Crime in Neighborhood
- Too expensive
- Others, please specify. _____

Would you like to move from your current home or apartment, and if so, please tell us why?

- Yes, because _____
- No

What are the reasons why you haven't moved yet? (Check All that Apply)

- Can't sell the house

- Can't afford to move
- Can't find an affordable place to live
- Due to a physical disability
- Need to find a new job
- Family Reasons
- Others, please specify._____

How many times did you move in the past five years?

- One
- Two
- Three
- Four
- Five or more

Home ambient settings & conditions

Approximately, which months of the year do you turn your heater on? _____

What is your set temperature for heating in your bedroom? _____

How satisfied are you with the temperature in your bedroom during your sleep during these heating months (season)?

- Extremely dissatisfied
- Dissatisfied
- Slightly Dissatisfied
- Slightly Satisfied
- Satisfied
- Extremely Satisfied

Approximately, which months of the year do you turn your air conditioning on? _____

What is your set temperature for air conditioning in your bedroom? _____

How satisfied are you with the temperature in your bedroom during your sleep during these cooling months (season)?

- Extremely dissatisfied
- Dissatisfied
- Slightly Dissatisfied
- Slightly Satisfied
- Satisfied
- Extremely Satisfied

Do you have a full level of control over the set temperature?

- Yes
- No
- Other? _____ (Please specify)

Sleep environmental satisfaction at home

How satisfied are you with the temperature in your bedroom during your sleep?
- Extremely dissatisfied
- Dissatisfied
- Slightly Dissatisfied
- Slightly Satisfied
- Satisfied
- Extremely Satisfied

How satisfied are you with the air quality in your bedroom during your sleep (i.e., stuffy/stale air, cleanliness, odors)?
- Extremely dissatisfied
- Dissatisfied
- Slightly Dissatisfied
- Slightly Satisfied
- Satisfied
- Extremely Satisfied

How satisfied are you with the amount of light in your bedroom during your sleep?
- Extremely dissatisfied
- Dissatisfied
- Slightly Dissatisfied
- Slightly Satisfied
- Satisfied
- Extremely Satisfied

How satisfied are you with the visual comfort of the lighting (i.e., reflections, contract) when you go to bed or are going back to bed (i.e., night trips to the bathroom)?
- Extremely dissatisfied
- Dissatisfied
- Slightly Dissatisfied
- Slightly Satisfied
- Satisfied
- Extremely Satisfied

How satisfied are you with your ability to adjust your lighting to meet your needs?
- Extremely dissatisfied
- Dissatisfied
- Slightly Dissatisfied
- Slightly Satisfied
- Satisfied
- Extremely Satisfied

How satisfied are you with the noise level in your bedroom at night and in the early morning?
- Extremely dissatisfied
- Dissatisfied
- Slightly Dissatisfied
- Slightly Satisfied

- Satisfied
- Extremely Satisfied

What are the sources of noise if you are dissatisfied with your noise level during sleep?

- Loud neighbors
- Loud appliances
- Traffic and urban city noise
- Loud AC/Heater
- Other: _____ (Please specify)

How satisfied are you with the size of your bedroom (or spaces available for sleep)?

- Extremely dissatisfied
- Dissatisfied
- Slightly Dissatisfied
- Slightly Satisfied
- Satisfied
- Extremely Satisfied

How satisfied are you with the access to the bathroom from your bed?

- Extremely dissatisfied
- Dissatisfied
- Slightly Dissatisfied
- Slightly Satisfied
- Satisfied
- Extremely Satisfied

Have you ever tripped or fallen during nighttime bathroom trips in the past year?

- Yes
- No
- Other: _____ (Please specify)

How satisfied are you with the comfort of your bedroom furnishings? (Bed frame, mattress, the total height of the bed, nightstand, pillows, and blankets)

- Extremely dissatisfied
- Dissatisfied
- Slightly Dissatisfied
- Slightly Satisfied
- Satisfied
- Extremely Satisfied

How satisfied are you with the general cleanliness of the overall house?

- Extremely dissatisfied
- Dissatisfied
- Slightly Dissatisfied
- Slightly Satisfied
- Satisfied
- Extremely Satisfied

How satisfied are you with the cleanliness of your bedroom?

- Extremely dissatisfied
- Dissatisfied

- Slightly Dissatisfied
- Slightly Satisfied
- Satisfied
- Extremely Satisfied

All things considered, how satisfied are you with your sleeping environment at home?

- Extremely dissatisfied
- Dissatisfied
- Slightly Dissatisfied
- Slightly Satisfied
- Satisfied
- Extremely Satisfied

What are the things that you wish to change for better sleep? _____

How many windows do you have in your bedroom?

- None
- One
- Two
- Three or more

Do you leave your window open during your sleep?

- Yes
- No
- N/A

Why? _____ (Please specify)

Do you leave your door open during your sleep?

- Yes
- No

Why? _____ (Please specify)

Please indicate true or false for the following statements based on your sleeping environment at home. (By The University of Pennsylvania School of Medicine)

1. _____ I keep the temperature in the bedroom so cold that I have 2 or more blankets on the bed to stay warm at night
2. _____ The blinds and curtains in the bedroom are so effective that at sunrise the room is so dark it's hard to tell that the sun came up.
3. _____ I have spent real time and money making sure that my mattress and pillow are perfect for me.
4. _____ During the night, my bedroom is insulated so well that I rarely if ever hear outside noise from the road, neighbors, etc.
5. _____ House noise from the radiators, floorboards, etc. is so minimal that I am rarely aware of such sounds.
6. _____ My home is a safe place. My partner and/or pet insure and/or the locks and alarm system and/or concern and support of my neighbors provide me a level of comfort such that I rarely if ever worry about being safe at night.

7. _____ On three or more nights per week, I engage in two or more of the following behaviors in the bedroom: watch TV, read, plan, worry, work, clean, or eat).
8. _____ My pets rarely if ever keep me from falling asleep or wake me up during the night.
9. _____ My bed partner's sleep schedule or "habits" while in bed (reading, moving about, stealing the covers, snoring, etc.) rarely if ever disturb my sleep.

REFERENCES

Alzheimer's Association. (2022). *Alzheimer's Disease Facts and Figures Special Report More Than Normal Aging: Understanding Mild Cognitive Impairment*. https://www.alz.org/media/Documents/alzheimers-facts-and-figures.pdf

Ancoli-Israel, S. (2005). Sleep and aging: prevalence of disturbed sleep and treatment considerations in older adults. *J Clin Psychiatry*, *66 Suppl 9*, 24-30; quiz 42-23.

Basner, M., & McGuire, S. (2018). WHO Environmental Noise Guidelines for the European Region: A Systematic Review on Environmental Noise and Effects on Sleep. *International Journal of Environmental Research and Public Health*, *15*(3), 519. https://doi.org/10.3390/ijerph15030519

Bastien, C. H., Vallières, A., & Morin, C. M. (2001). Validation of the Insomnia Severity Index as an outcome measure for insomnia research. *Sleep Medicine*, *2*(4), 297-307.

Beccuti, G., & Pannain, S. (2011). Sleep and obesity. *Current Opinion in Clinical Nutrition and Metabolic Care*, *14*(4), 402-412. https://doi.org/10.1097/mco.0b013e3283479109

Benson, J. A., McSorley, V. E., Hawkley, L. C., & Lauderdale, D. S. (2021). Associations of loneliness and social isolation with actigraph and self-reported sleep quality in a national sample of older adults. *Sleep*, *44*(1). https://doi.org/10.1093/sleep/zsaa140

Blake K, K. R., Simic A. (2007). Measuring Overcrowding in Housing.

Bozick, R., Troxel, W. M., & Karoly, L. A. (2021). Housing insecurity and sleep among welfare recipients in California. *Sleep*, *44*(7). https://doi.org/10.1093/sleep/zsab005

Bronfenbrenner, U. (1979). *The ecology of human development: Experiments by nature and design*. Harvard university press.

Buxton, O. M., & Marcelli, E. (2010). Short and long sleep are positively associated with obesity, diabetes, hypertension, and cardiovascular disease among adults in the United States. *Social Science & Medicine*, *71*(5), 1027-1036. https://doi.org/10.1016/j.socscimed.2010.05.041

Buysse, D. J., Reynolds, C. F., Monk, T. H., Berman, S. R., & Kupfer, D. J. (1989). The Pittsburgh sleep quality index: A new instrument for psychiatric practice and research. *Psychiatry Research*, *28*(2), 193-213. https://doi.org/https://doi.org/10.1016/0165-1781(89)90047-4

Cajochen, C. (2007). Alerting effects of light. *Sleep Med Rev*, *11*(6), 453-464. https://doi.org/10.1016/j.smrv.2007.07.009

CDC. (2019). *Subjective Cognitive Decline - A Public Health Issue*. Centers for Disease Control and Prevention. Retrieved July 19 2022 from https://www.cdc.gov/aging/data/subjective-cognitive-decline-brief.html

CDC. (2022). *Sleep and Chronic Disease*. https://www.cdc.gov/sleep/about_sleep/chronic_disease.html

Chambers, E. C., Pichardo, M. S., & Rosenbaum, E. (2016). Sleep and the Housing and Neighborhood Environment of Urban Latino Adults Living in Low-Income Housing: The AHOME Study. *Behavioral Sleep Medicine*, *14*(2), 169-184. https://doi.org/10.1080/15402002.2014.974180

Cohen, S., Kamarck, T., & Mermelstein, R. (1983). A global measure of perceived stress. *Journal of health and social behavior*, 385-396.

Cole, G. E., Tucker, L. A., & Friedman, G. M. (1986). Measures of Objective and Subjective Stress by Level of Income. *Psychological Reports*, *59*(1), 139-142. https://doi.org/10.2466/pr0.1986.59.1.139

Collins, K. J., Exton-Smith, A. N., & Dore, C. (1981). Urban hypothermia: preferred temperature and thermal perception in old age. *BMJ*, *282*(6259), 175-177. https://doi.org/10.1136/bmj.282.6259.175

Desaulniers, J., Desjardins, S., Lapierre, S., & Desgagne, A. (2018). Sleep Environment and Insomnia in Elderly Persons Living at Home. *J Aging Res*, *2018*, 8053696. https://doi.org/10.1155/2018/8053696

Elmenhorst, E. M., Elmenhorst, D., Luks, N., Maass, H., Vejvoda, M., & Samel, A. (2008). Partial sleep deprivation: impact on the architecture and quality of sleep. *Sleep Med*, *9*(8), 840-850. https://doi.org/10.1016/j.sleep.2007.07.021

Gauthier, S., Reisberg, B., Zaudig, M., Petersen, R. C., Ritchie, K., Broich, K., Belleville, S., Brodaty, H., Bennett, D., Chertkow, H., Cummings, J. L., de Leon, M., Feldman, H., Ganguli, M., Hampel, H., Scheltens, P., Tierney, M. C., Whitehouse, P., & Winblad, B. (2006). Mild cognitive impairment. *The Lancet*, *367*(9518), 1262-1270. https://doi.org/https://doi.org/10.1016/S0140-6736(06)68542-5

Gellis, L. A., Lichstein, K. L., Scarinci, I. C., Durrence, H. H., Taylor, D. J., Bush, A. J., & Riedel, B. W. (2005). Socioeconomic status and insomnia. *J Abnorm Psychol*, *114*(1), 111-118. https://doi.org/10.1037/0021-843x.114.1.111

Grandner, M. A., Jackson, N. J., Izci-Balserak, B., Gallagher, R. A., Murray-Bachmann, R., Williams, N. J., Patel, N. P., & Jean-Louis, G. (2015). Social and Behavioral Determinants of Perceived Insufficient Sleep [Original Research]. *Frontiers in Neurology*, *6*. https://doi.org/10.3389/fneur.2015.00112

Grandner, M. A., Patel, N. P., Gehrman, P. R., Xie, D., Sha, D., Weaver, T., & Gooneratne, N. (2010). Who gets the best sleep? Ethnic and socioeconomic factors related to

sleep complaints. *Sleep Medicine*, *11*(5), 470-478. https://doi.org/10.1016/j.sleep.2009.10.006

Guergova, S., & Dufour, A. (2011). Thermal sensitivity in the elderly: a review. *Ageing Res Rev*, *10*(1), 80-92. https://doi.org/10.1016/j.arr.2010.04.009

Hashiguchi, N., Tochihara, Y., Ohnaka, T., Tsuchida, C., & Otsuki, T. (2004). Physiological and Subjective Responses in the Elderly When Using Floor Heating and Air Conditioning Systems. *Journal of PHYSIOLOGICAL ANTHROPOLOGY and Applied Human Science*, *23*(6), 205-213. https://doi.org/10.2114/jpa.23.205

Herrmann, B., Maess, B., & Johnsrude, I. S. (2018). Aging Affects Adaptation to Sound-Level Statistics in Human Auditory Cortex. *The Journal of Neuroscience*, *38*(8), 1989-1999. https://doi.org/10.1523/jneurosci.1489-17.2018

Ichimori, A., Tsukasaki, K., & Koyama, E. (2015). Illuminance, Subjective Sleep Quality, and Psychosomatic Health in Elderly Individuals Requiring Care: A Survey of Japan's Hokuriku Region in Winter. *J Community Health Nurs*, *32*(2), 104-114. https://doi.org/10.1080/07370016.2015.1026158

Johnson, D. A., Jackson, C. L., Guo, N., Sofer, T., Laden, F., & Redline, S. (2021). Perceived home sleep environment: associations of household-level factors and in-bed behaviors with actigraphy-based sleep duration and continuity in the Jackson Heart Sleep Study. *Sleep*, *44*(11). https://doi.org/10.1093/sleep/zsab163

Kahneman, D., & Deaton, A. (2010). High income improves evaluation of life but not emotional well-being. *Proceedings of the National Academy of Sciences*, *107*(38), 16489-16493. https://doi.org/doi:10.1073/pnas.1011492107

Killgore, W. D. S. (2010). Effects of sleep deprivation on cognition. 105-129. https://doi.org/10.1016/b978-0-444-53702-7.00007-5

Lee, M., Choh, A. C., Demerath, E. W., Knutson, K. L., Duren, D. L., Sherwood, R. J., Sun, S. S., Chumlea, W. C., Towne, B., Siervogel, R. M., & Czerwinski, S. A. (2009). Sleep disturbance in relation to health-related quality of life in adults: The fels longitudinal study. *JNHA - The Journal of Nutrition, Health and Aging*, *13*(6), 576-583. https://doi.org/10.1007/s12603-009-0110-1

Lewy, A. J., Wehr, T. A., Goodwin, F. K., Newsome, D. A., & Markey, S. P. (1980). Light Suppresses Melatonin Secretion in Humans. *Science*, *210*(4475), 1267-1269. https://doi.org/doi:10.1126/science.7434030

Martin, J. L., & Ancoli-Israel, S. (2008). Sleep Disturbances in Long-Term Care. *Clinics in Geriatric Medicine*, *24*(1), 39-50. https://doi.org/10.1016/j.cger.2007.08.001

McCurry, S. M., Pike, K. C., Vitiello, M. V., Logsdon, R. G., Larson, E. B., & Teri, L. (2011). Increasing walking and bright light exposure to improve sleep in community-dwelling persons with Alzheimer's disease: results of a randomized,

controlled trial. *J Am Geriatr Soc*, *59*(8), 1393-1402. https://doi.org/10.1111/j.1532-5415.2011.03519.x

McKinnon, A., Terpening, Z., Hickie, I. B., Batchelor, J., Grunstein, R., Lewis, S. J., & Naismith, S. L. (2014). Prevalence and predictors of poor sleep quality in mild cognitive impairment. *Journal of geriatric psychiatry and neurology*, *27*(3), 204-211.

Mishima, K., Okawa, M., Shimizu, T., & Hishikawa, Y. (2001). Diminished Melatonin Secretion in the Elderly Caused by Insufficient Environmental Illumination. *The Journal of Clinical Endocrinology & Metabolism*, *86*(1), 129-134. https://doi.org/10.1210/jcem.86.1.7097

Moore, P. J., Adler, N. E., Williams, D. R., & Jackson, J. S. (2002). Socioeconomic status and health: the role of sleep. *Psychosom Med*, *64*(2), 337-344. https://doi.org/10.1097/00006842-200203000-00018

Muehlroth, B. E., & Werkle-Bergner, M. (2020). Understanding the interplay of sleep and aging: Methodological challenges [https://doi.org/10.1111/psyp.13523]. *Psychophysiology*, *57*(3), e13523. https://doi.org/https://doi.org/10.1111/psyp.13523

Mujuru, P., Jean-Francois, B., & Pérez-Stable, E. J. (2022). National Institute on Minority Health and Health Disparities Specialized Centers of Excellence on Minority Health and Health Disparities. *American Journal of Preventive Medicine*, *63*(1), S6.

Nasreddine, Z. S., Phillips, N. A., Bã©Dirian, V. R., Charbonneau, S., Whitehead, V., Collin, I., Cummings, J. L., & Chertkow, H. (2005). The Montreal Cognitive Assessment, MoCA: A Brief Screening Tool For Mild Cognitive Impairment. *Journal of the American Geriatrics Society*, *53*(4), 695-699. https://doi.org/10.1111/j.1532-5415.2005.53221.x

Natsume, K., Ogawa, T., Sugenoya, J., Ohnishi, N., & Imai, K. (1992). Preferred ambient temperature for old and young men in summer and winter. *Int J Biometeorol*, *36*(1), 1-4. https://doi.org/10.1007/bf01208726

Obayashi, K., Saeki, K., Iwamoto, J., Okamoto, N., Tomioka, K., Nezu, S., Ikada, Y., & Kurumatani, N. (2014). Effect of exposure to evening light on sleep initiation in the elderly: a longitudinal analysis for repeated measurements in home settings. *Chronobiol Int*, *31*(4), 461-467. https://doi.org/10.3109/07420528.2013.840647

Obayashi, K., Saeki, K., & Kurumatani, N. (2014). Association between light exposure at night and insomnia in the general elderly population: the HEIJO-KYO cohort. *Chronobiol Int*, *31*(9), 976-982. https://doi.org/10.3109/07420528.2014.937491

Obayashi, K., Saeki, K., & Kurumatani, N. (2018). Bedroom Light Exposure at Night and the Incidence of Depressive Symptoms: A Longitudinal Study of the HEIJO-KYO

Cohort. *American Journal of Epidemiology*, *187*(3), 427-434. https://doi.org/10.1093/aje/kwx290

Ogilvie, R. P., & Patel, S. R. (2017). The epidemiology of sleep and obesity. *Sleep Health*, *3*(5), 383-388. https://doi.org/10.1016/j.sleh.2017.07.013

Ohayon, M. M., Carskadon, M. A., Guilleminault, C., & Vitiello, M. V. (2004). Meta-Analysis of Quantitative Sleep Parameters From Childhood to Old Age in Healthy Individuals: Developing Normative Sleep Values Across the Human Lifespan. *Sleep*, *27*(7), 1255-1273. https://doi.org/10.1093/sleep/27.7.1255

Ohnaka, T., Tochihara, Y., & Kanda, K. (1995). Body movements of the elderly during sleep and thermal conditions in bedrooms in summer. *Appl Human Sci*, *14*(2), 89-93. https://doi.org/10.2114/ahs.14.89

Okamoto-Mizuno, K., & Tsuzuki, K. (2010). Effects of season on sleep and skin temperature in the elderly. *Int J Biometeorol*, *54*(4), 401-409. https://doi.org/10.1007/s00484-009-0291-7

Okamoto-Mizuno, K., Tsuzuki, K., & Mizuno, K. (2004). Effects of mild heat exposure on sleep stages and body temperature in older men. *International Journal of Biometeorology*, *49*(1). https://doi.org/10.1007/s00484-004-0209-3

Owsley, C. (2011). Aging and vision. *Vision research*, *51*(13), 1610-1622.

Park, J. H., Yoo, M. S., & Bae, S. H. (2013). Prevalence and predictors of poor sleep quality in <scp>K</scp> orean older adults. *International Journal of Nursing Practice*, *19*(2), 116-123. https://doi.org/10.1111/ijn.12047

Radloff, L. S. (1977). The CES-D scale: A self-report depression scale for research in the general population. *Applied psychological measurement*, *1*(3), 385-401.

Reither, E. N., Krueger, P. M., Hale, L., Reiter, E. M., & Peppard, P. E. (2014). Ethnic variation in the association between sleep and body mass among US adolescents. *International Journal of Obesity*, *38*(7), 944-949. https://doi.org/10.1038/ijo.2014.18

Sabia, S., Fayosse, A., Dumurgier, J., Van Hees, V. T., Paquet, C., Sommerlad, A., Kivimäki, M., Dugravot, A., & Singh-Manoux, A. (2021). Association of sleep duration in middle and old age with incidence of dementia. *Nature Communications*, *12*(1). https://doi.org/10.1038/s41467-021-22354-2

Saeki, K., Obayashi, K., Tone, N., & Kurumatani, N. (2015). A warmer indoor environment in the evening and shorter sleep onset latency in winter: The HEIJO-KYO study. *Physiol Behav*, *149*, 29-34. https://doi.org/10.1016/j.physbeh.2015.05.022

Saeki, K., Obayashi, K., Tone, N., & Kurumatani, N. (2015). A warmer indoor environment in the evening and shorter sleep onset latency in winter: The HEIJO-KYO study. *Physiology & Behavior*, *149*, 29-34. https://doi.org/10.1016/j.physbeh.2015.05.022

Sander, B., Markvart, J., Kessel, L., Argyraki, A., & Johnsen, K. (2015). Can sleep quality and wellbeing be improved by changing the indoor lighting in the homes of healthy, elderly citizens? *Chronobiol Int*, *32*(8), 1049-1060. https://doi.org/10.3109/07420528.2015.1056304

Shankar, A., McMunn, A., Demakakos, P., Hamer, M., & Steptoe, A. (2017). Social isolation and loneliness: Prospective associations with functional status in older adults. *Health Psychol*, *36*(2), 179-187. https://doi.org/10.1037/hea0000437

Shi, L., Chen, S.-J., Ma, M.-Y., Bao, Y.-P., Han, Y., Wang, Y.-M., Shi, J., Vitiello, M. V., & Lu, L. (2018). Sleep disturbances increase the risk of dementia: A systematic review and meta-analysis. *Sleep Medicine Reviews*, *40*, 4-16. https://doi.org/https://doi.org/10.1016/j.smrv.2017.06.010

Shishegar, N., Boubekri, M., Stine-Morrow, E. A. L., & Rogers, W. A. (2021). Tuning environmental lighting improves objective and subjective sleep quality in older adults. *Building and Environment*, *204*, 108096. https://doi.org/https://doi.org/10.1016/j.buildenv.2021.108096

Spitzer, R. L., Kroenke, K., Williams, J. B. W., & Löwe, B. (2006). A Brief Measure for Assessing Generalized Anxiety Disorder. *Archives of Internal Medicine*, *166*(10), 1092. https://doi.org/10.1001/archinte.166.10.1092

Suzuki, J.-i., Isobe, M., Morishita, R., & Nagai, R. (2009). Tea Polyphenols Regulate Key Mediators on Inflammatory Cardiovascular Diseases. *Mediators of Inflammation*, *2009*, 494928. https://doi.org/10.1155/2009/494928

The University of Pennsylvania School of Medicine. *Sleep environment questionnaire*. Retrieved May from https://www.med.upenn.edu/cbti/assets/user-content/documents/SLEEPENVIRONMENTQUESTIONNAIRE.doc

Thichumpa, W., Howteerakul, N., Suwannapong, N., & Tantrakul, V. (2018). Sleep quality and associated factors among the elderly living in rural Chiang Rai, northern Thailand. *Epidemiol Health*, *40*, e2018018. https://doi.org/10.4178/epih.e2018018

Tholking, T. W., Lamers, E. C. T., & Olde Rikkert, M. G. M. (2020). A Guiding Nightlight Decreases Fear of Falling and Increases Sleep Quality of Community-Dwelling Older People: A Quantitative and Qualitative Evaluation. *Gerontology*, *66*(3), 295-303. https://doi.org/10.1159/000504883

Tsuzuki, K., Mori, I., Sakoi, T., & Kurokawa, Y. (2015). Effects of seasonal illumination and thermal environments on sleep in elderly men. *Building and Environment*, *88*, 82-88. https://doi.org/10.1016/j.buildenv.2014.10.001

Turner, P. L., & Mainster, M. A. (2008). Circadian photoreception: ageing and the eye's important role in systemic health. *Br J Ophthalmol*, *92*(11), 1439-1444. https://doi.org/10.1136/bjo.2008.141747

U.S. Census Bureau. (2020). *65 and Older Population Grows Rapidly as Baby Boomers Age*. https://www.census.gov/newsroom/press-releases/2020/65-older-population-grows.html#:~:text=The%2065%2Dand%2Dolder%20population,1%2C688%2C924)%20from%202018%20to%202019.

Wallace-Guy, G. M., Kripke, D. F., Jean-Louis, G., Langer, R. D., Elliott, J. A., & Tuunainen, A. (2002). Evening light exposure: implications for sleep and depression. *J Am Geriatr Soc*, *50*(4), 738-739. https://doi.org/10.1046/j.1532-5415.2002.50171.x

Whinnery, J., Jackson, N., Rattanaumpawan, P., & Grandner, M. A. (2014). Short and Long Sleep Duration Associated with Race/Ethnicity, Sociodemographics, and Socioeconomic Position. *Sleep*, *37*(3), 601-611. https://doi.org/10.5665/sleep.3508

Willette-Murphy, K., Todero, C., & Yeaworth, R. (2006). Mental health and sleep of older wife caregivers for spouses with Alzheimer's disease and related disorders. *Issues in Mental Health Nursing*, *27*(8), 837-852. https://doi.org/10.1080/01612840600840711

World Health Organization. Regional Office for, E. (2009). *Night noise guidelines for Europe*. World Health Organization. Regional Office for Europe. https://apps.who.int/iris/handle/10665/326486

Yan, Y., Lan, L., Zhang, H., Sun, Y., Fan, X., Wyon, D. P., & Wargocki, P. (2022). Association of bedroom environment with the sleep quality of elderly subjects in summer: A field measurement in Shanghai, China. *Building and Environment*, *208*. https://doi.org/10.1016/j.buildenv.2021.108572

Yang, E., Ismail, A., Kim, Y., Erdogmus, E., Boron, J., Goldstein, F., DuBose, J., & Zimring, C. (2022). Multidimensional Environmental Factors and Sleep Health for Aging Adults: A Focused Narrative Review. *International Journal of Environmental Research and Public Health*, *19*(23), 15481. https://www.mdpi.com/1660-4601/19/23/15481

Youngstedt, S. D., Leung, A., Kripke, D. F., & Langer, R. D. (2004). Association of morning illumination and window covering with mood and sleep among post-menopausal women. *Sleep Biol Rhythms*, *2*(3), 174-183. https://doi.org/10.1111/j.1479-8425.2004.00139.x

Yu, B., Steptoe, A., Niu, K., Ku, P.-W., & Chen, L.-J. (2018). Prospective associations of social isolation and loneliness with poor sleep quality in older adults. *Quality of Life Research*, *27*(3), 683-691. https://doi.org/10.1007/s11136-017-1752-9