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Non-pharmacological Methods of Alleviating Sleep Disturbances in Alzheimer's Disease

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Millions of individuals worldwide suffer from Alzheimer's Disease (AD), a neurodegenerative condition that mostly affects the elderly. Also, sleep disturbances are one of the most prevalent indicators of AD and may significantly impact both patients and their caregiver's quality of life.

The purpose of this scoping review was to provide an overview of the current state of knowledge and identify potential gaps in non-pharmacological methods of alleviating sleep disturbances in AD for future investigation. And the aim is to identify and describe the existing literature on non-pharmacological methods used to alleviate sleep disturbances for individuals with AD and their caretakers.

Data for this study were gathered using scientific databases such as CINAHL, Pubmed and MEDLINE related to non-pharmacological methods of alleviating sleep disturbances in AD. Using established inclusion and exclusion criteria, the search was narrowed down, and 14 articles were selected.

The findings addressed non-pharmacological methods that have been explored to alleviate sleep disturbances in individuals with AD and the potential gaps for future investigations. We found that light treatment is effective in managing sleep disturbances. Additionally, other interventions like behavioral interventions, physical activity and aroma bath salt interventions have been designed to alleviate sleep disturbances experienced by patients with AD. Likewise, a diverse range of outcomes, with some studies indicating improvements in sleep quality or alertness throughout the day and others fail to demonstrate any noticeable gains. Furthermore, primary findings indicated that light treatment was effective in managing sleep disturbances.

We conclude that this diverse range of non-pharmacological interventions, including light therapy, aroma bath salts, circadian-effective lighting, and exercise have demonstrated positive effects on sleep parameters, including improved sleep quality, increased sleep duration, and enhanced sleep efficiency. However, quality of life and caregiver burden were not central to the studies, focusing primarily on sleep and related outcomes in individuals with dementia.

This may indicate a promising avenue for future studies that involves combining multiple non-pharmacological measure for sleep interventions.

Keywords	Alzheimer's disease, Alzheimer, Alzheimer's, sleep disorder, sleep deprivation, sleep, sleep quality, sleep hygiene, sleep duration, alleviate, relieve, wellbeing, well-being

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1 Introduction

A neurodegenerative condition that primarily affects the elderly is Alzheimer's disease (AD). The cerebral cortex, which is important for thought, learning, and memory, is impacted by the condition. The most prevalent type of dementia, AD, is a more general term for a group of brain illnesses marked by functional deficits, behavioral abnormalities, and cognitive impairment. Even though AD is a well-known and researched subtype, dementia must be understood as a complex and diverse condition that presents a major problem for society and healthcare. (Alzheimer’s Society 2019; Boustani, Peterson, Hanson, Harris, and Lohr 2003: 927).

Sleep problems are among the most prevalent symptoms of AD, and they can significantly lower patients' and caregivers' quality of life. Compared to other populations, people with AD are more prone to develop sleep disturbances; over the course of the disease, up to 45% of patients report experiencing sleep problems. This can manifest in a number of ways, including troubling sleeping at night, daytime sleepiness, fragmented sleep, and disruptions to the circadian rhythm. Furthermore, it has been demonstrated that AD patients' behavioral symptoms and cognitive decline are made worse by these sleep abnormalities. Sleep difficulties can have a substantial effect on those with AD. Studies have shown a connection between poor sleep quality and a greater risk of dementia and an accelerated rate of cognitive decline. Sleep disorders also lead to a higher care burden and decreased quality of living for patients and caregivers. (Ettore, Bakardjian, Nogueira, Habert, Gabelle, Dubois, Robert, and David 2019: 2; Minakawa, Wada and Nagai 2019: 2.)

The exact mechanisms underlying sleep disturbances in AD are not yet fully understood, but several factors may contribute to their development. These include changes in brain chemistry, disruptions to circadian rhythms, alterations in sleep architecture, and other comorbid conditions, such as sleep apnea and depression. Sleep problems may have serious effects on one's physical and mental well-being, ability to function throughout the day, and general quality of life, therefore it's critical to identify and address them. (Liu, Xie, Meng, and Kang 2019: 3.)

It is crucial to recognize and provide details about sleep disturbances experienced by individuals with AD when considering non-pharmacological methods to address them. By focusing on non-pharmacological approaches, this research highlights a patient-centered approach, minimizing potential side effects associated with pharmaceuticals and promoting a

higher quality of life for AD patients. The findings in this review can guide clinical practice by offering healthcare professionals and caregivers a better understanding of effective non-pharmacological interventions, potentially enhancing sleep quality, cognitive functioning, and overall well-being among AD patients. Additionally, it emphasizes the potential to reduce caregiver burden and healthcare costs.

This study aims to identify and describe the existing literature on non-pharmacological methods used to alleviate sleep disturbances in individuals with AD, focusing on interventions that nurses can implement to enhance sleep quality in AD patients and improve the overall quality of life for both patients and caregivers. Likewise, this scoping review attempts to improve the management of AD patients by offering a thorough summary of the present state of knowledge and pointing out possible areas for further research.

2 Background and key terms

2.1 Understanding Dementia and Its Prevalent Causes

Dementia occurs when memory, thinking, and behavior decline, affecting daily life because of brain diseases. Moreover, dementia can be triggered by a range of diseases that affect memory, thinking, and daily functioning, as well as injuries that affect the brain. Various illnesses can lead to dementia, which involves memory and thinking problems. The two most commontypes of dementia are AD and vascular dementia (VD), however some people might have both. Although conditions like low thyroid or low vitamin B12 levels are sometimes believed to cause dementia, only a small percentage of mild to moderate dementia cases are fully reversible, typically less than 1.5%. The World Health Organization (WHO) has declared dementia to be a major worldwide public health problem in recent years. Approximately, 10 million new cases are recorded yearly, and it affects approximately 55 million individuals globally. (Boustani et al. 2003: 927; World Health Organization 2023.)

2.2 The Dominance of Alzheimer's Disease

One prominent contributor to dementia is AD, marked by the buildup of abnormal proteins, like beta-amyloid and phosphorylated tau, along with the deterioration of neurons. Thus, these Alzheimer's-related brain changes are a major factor in the development of dementia. AD makes about 60–70% of cases, making it the most prevalent forms of dementia. Furthermore, AD is a major cause of disability and dependency among the elderly population. Likewise, in

the recent statistical report, it is responsible for the seventh leading cause of death globally. Unfortunately, AD symptoms worsen as the disease progresses. Memory and thinking problems are often the initial noticeable symptoms, because the brain areas responsible for these functions are affected first. (Alzheimer's Society 2019; World Health Organization 2023.)

AD is associated with multiple hypotheses regarding its causes. Firstly, these hypotheses include a breakdown in the brain's cholinergic system that affects the neurotransmitter acetylcholine and is thought to contribute to cognitive decline in AD. Likewise, when calcium levels in neurons are elevated, it makes them vulnerable to external factors. Moreover, another theory suggests the importance of maintaining a stable brain environment through proper blood circulation, because issues with this system will potentially cause brain dysfunction. Furthermore, the roles of microglia and astrocytes with high levels of inflammatory molecules are linked to AD progression, as well as the imbalances in copper, zinc, and iron. Notably, beta-amyloid plaques and tangled tau proteins are said to be hallmarks of AD which disrupt cell function and trigger inflammation. The accumulation of these abnormal proteins is thought to be caused by a combination of genetic, environmental, and lifestyle factors. (Alzheimer's Society 2019; Pei-Pei et al. 2019: 3.)

2.3 Sleep, Circadian Rhythms, and the Suprachiasmatic Nucleus (SCN)

Sleep is essential for preserving mental and physical well-being, memory consolidation, and cognitive performance. The process of sleep is multifaceted, controlled by distinct brain regions, and closely related to neurological processes. Among the major roles in sleep and circadian regulation are the anterior hypothalamus, reticular activating system, suprachiasmatic nucleus (SCN), and pineal gland. The interaction of homeostatic and circadian mechanisms affects sleep. "Sleep drive," or the desire to sleep greater the longer one stays awake, is a result of homeostatic mechanisms. Melatonin production, body temperature, and the 24-hour sleep-wake cycle are just a few of the physiological and neurobehavioral processes that are regulated by the circadian timing system, which is led by the SCN. Due to the SCN's sensitivity to light, exposure to light reduces melatonin production, which affects sleep. Reticulated activating systems support the maintenance of wakefulness and awareness of surroundings. (Deschenes and McCurry 2019: 20.)

The SCN, an endogenous biological clock, is part of a complex system that regulates 24 hour biological cycles known as circadian rhythms, which in turn control a variety of physiological and behavioral processes. As the primary pacemaker of the circadian system, the SCN, which has roughly 10,000 neurons in mice and 50,000 neurons in humans, is found in the brain. Numerous processes, such as eating habits, hormone levels, body temperature, and rest-

activity behavior, are regulated by this internal clock. The quality of sleep, alertness, mental health, motor control, and metabolism are all impacted by these rhythms. They are synchronized with the solar day. Normal cycles of rest-activity, sleep, and alertness can become disrupted as a result of circadian system issues, which are frequently seen in neurodegenerative diseases like AD, Parkinson's disease (PD), and Huntington's disease (HD). Such disruption could serve as the reason behind the disease process in addition to increasing morbidity and lowering quality of life. Thus, it is essential to comprehend and treat circadian rhythm abnormalities in these circumstances in order to preserve homeostasis and general health. Disturbances in circadian regulation can have a substantial impact on health, leading to heightened chances of ailments such as metabolic syndrome, obesity, diabetes, and cardiovascular diseases. This regulation encompasses more than just sleep patterns and includes numerous physiological and biochemical processes. Therefore, the circadian clocks are an integral part of our biological processes, and maintaining a state of optimal wellbeing and health requires that they remain in sync with the external environment. (Sukumaran, Almon, DuBois, and Jusko 2010: 907; Videnovic, Lazar, Barker and Overeem 2014: 683.)

Rapid eye movement (REM) and non-rapid eye movement (NREM), which has three stages known as N1, N2, and N3, are the two phases of sleep. The first stage, which is marked by easy awakenings, is the change from wakefulness to sleep. In stage 2, "sleep spindles" and "K complexes" on the electroencephalogram (EEG) indicate a loss of conscious consciousness. Deep sleep stages 3 and 4 are characterized by slower brain waves and more difficulty waking up. The deepest stage of NREM sleep is referred to as slow wave sleep (SWS). The last stage of sleep connected to dreaming is called REM sleep, and it is characterized by twitching muscles, fast eye movements, and increased pulse and breathing rates. Stages 3 and 4, as well as REM sleep, diminish considerably with age, which may be a factor in older individuals' inability to fall back asleep, weariness during the day, and numerous nightly awakenings. REM sleep generally remains consistent until around the age of 80 when it also becomes shorter. As such, this can lead to disruptions during sleep, a reduced deep SWS, shorter overall duration of sleep, and longer periods of lighter N1 and N2 sleep. (Ettore et al 2019: 2; Deschenes et al. 2019: 21.)

2.4 Aging, Sleep Patterns, and Cognitive Decline

As we grow older our sleep patterns tend to change. Experiencing quality of sleep is often associated with aging and this can be even more noticeable for individuals with AD. In addition, recent studies have proposed that sleep disturbances might increase the risk of cognitive decline and AD. A meta-analysis revealed that various issues related to disrupted sleep

patterns such as difficulty falling asleep, frequent awakenings or circadian rhythm problems were strongly linked to a significantly higher risk of cognitive impairment, preclinical stages of AD and ultimately an AD diagnosis. (Chang, Chaput, Roberts Jayaraman, and Do 2018: 404; Minakawa et al. 2019: 2.)

Sleep disturbances accelerate AD's progression. Disturbances in regular sleep cycles, such as challenges in starting, sticking with, or reaching sound sleep, can lead to sleep disturbances and poorer quality and alertness during the day. Since the circadian rhythms problems frequently occur in AD patients, this study is relevantly focused on them. Even though pharmacological options, such as benzodiazepines (BZDs) and Z-drugs (such as zolpidem, zopiclone, and zaleplon) are available to treat sleep problems, they come with various side effects. It includes memory problems, the need for higher doses over time, the potential for misuse, and the risk of developing dependency. In this case, pharmacological interventions may not be the best solution. Alternatively, using non-pharmacological interventions treatments and therapies that do not involve the use of drugs may avoid these side effects, especially potential drug interactions and polypharmacy issues common in the elderly. Polypharmacy is relevant when discussing the potential side effects and complications associated with taking numerous medications, especially in elderly individuals who may be dealing with multiple health issues. As a result, reducing polypharmacy is one of the benefits of non-pharmacological interventions, as they often involve fewer medications and therefore lower the risk of complications associated with multiple drugs. In this case, treatments like light therapy, physical activity, and behavioral strategies offer a safer and more personalized approach for managing sleep disturbances in individuals with AD. Thus, reducing the reliance on pharmacological treatments, non-pharmacological methods hold the potential to enhance the overall well-being of AD patients, potentially improving their quality of life. (Craig, Hart, and Passmore 2006: 1003; Atkin, Comai, and Gobi 2018: 199; Midão, Giardini, Menditto, Kardas, and Costa 2018: 213; Burke, Hu, Spadola, Burgess, Li, and Cadet 2019: 1; World Health Organization 2023.)

2.5 Previous Non-Pharmacological Approaches for Sleep Disturbances in AD

Previous research has explored a range of non-pharmacological methods aimed at alleviating sleep disturbances in individuals with AD. Notable studies have investigated approaches such as light therapy, cognitive behavioral therapy, and lifestyle modifications. For example, a study by Rheaume et al. (1998) showed how beneficial customized light exposure is for enhancing sleep patterns, including those associated with circadian sleep issues, insomnia, and sleep disturbances linked to dementia and AD. Nonetheless, it is important to note that the majority

of effect sizes indicate relatively only small to medium effects. (Rheaume and Manning and Harper and Volicer 1998: 291.) Similarly, another study conducted by Mishima et al. (1994) suggested morning bright light serves as a potent regulator capable of restoring disrupted sleep patterns and significantly decreasing the occurrence of behavioral issues in elderly individuals with dementia. (Mishima, Okawa, Hishikawa, Hozumi, Hori, and Takahashi 1994: 2.)

2.6 Measurement Methods: Lux Levels and Actigraphy

A study conducted by Mishima et al. (1994) incorporated lux levels and employed continuous observations by nursing staff who kept a sleep diary to monitor patient activity and rest patterns, whereas Rheume et al. (1998) incorporated lux levels and utilized actigraphy to measure patient movements and sleep patterns. Lux is used to quantify how much light is present in a given area, with higher lux values indicating brighter illumination. It's a common unit of measurement in lighting design and related fields. On the other hand, actigraphy involves the use of a small, wrist-worn device (an actigraph) that measures movements, and provides data on sleep patterns, circadian rhythms, and activity levels. (Mishima et al. 1994: 2; Rheaume et al 1998: 292.)

2.7 The Behavioral Strategies and Theory of Planned Behavior

A study conducted by Teri et al., (1991) delved into the benefits of cognitive and behavioral therapies, which provided insights into how this non-pharmacological intervention can enhance sleep quality and overall well-being in individuals with AD. (Teri and Gallagher-Thompson 1991: 415.) Additionally, Someren et al. (1993) reviewed various treatments for circadian rhythm disturbances in aging and dementia. These treatments include bright light therapy, which can help regulate circadian rhythms; exercise, which may improve sleep quality and cognitive performance in the elderly; passive body heating, such as warm baths, as an alternative to exercise; deprivation of daytime naps and time in bed restriction to enhance sleep quality for some individuals; and social interaction's potential but limited role in addressing sleep-wake rhythm disorders in demented patients. (Someren, Mirmiran, and Swaab 1993: 242.)

The importance of non-pharmacological methods, like behavioral strategies, in treating sleep disturbances problems is becoming increasingly acknowledged. The Theory of Planned Behavior (TPB) provides a useful framework for comprehending and putting behavioral interventions into practice in this setting. According to the TPB, one can predict an individual's behavior based on their intentions and sense of control over that behavior. Intentions and

perceived control must be precisely linked to the desired behavior and must hold steady until the behavior takes place in order for predictions to be accurate. This theory aids in our comprehension of how people's intentions and convictions regarding their ability to control behavior affect their deeds. In the case of non-pharmacological strategies, perceived control includes factors such as the patient's physical and cognitive capabilities, the availability of necessary resources, and any potential barriers that may impede successful implementation.

This scoping review identifies and describes the non-pharmacological therapies in lessening the frequent sleep disturbances experienced by individuals with AD. These therapies, most notably light therapy, can balance circadian rhythms, which offers a potential treatment option for the sleep problems that affect individuals with AD. Other interventions that may help with this include physical activity and behavioral strategies. We specifically looked into their efficacy and possible limitations, offering information that can point out areas in which more study is required.

3 Purpose, aims and research questions

The purpose is to provide an overview of the current state of knowledge and identify potential gaps in non-pharmacological methods of alleviating sleep disturbances in AD for future investigation.

The aim is to identify and describe the existing literature on non-pharmacological methods used to alleviate sleep disturbances for individuals with AD and their caretakers.

The research questions are:

1. What non-pharmacological methods have been explored to alleviate sleep disturbances in individuals with AD?

2. What are the potential gaps for future investigations?

4 Methodology and Methods

4.1 Data collection method

The study utilized a descriptive study approach under the direction of a scoping review. Because scoping reviews adhere to a structured process, they are relatively similar to systematic reviews. Scoping review serve to scope present studies and provide guidance for future studies. Their primary objective is to identify and map the evidence that is already accessible (Munn, Peters, Stern, Tufanaru, McArthur, and Aromataris 2018).

A scoping study's methodological framework used by Levac et al. (2010) is categorized into the following stages: Step one involves defining the goal and objective and making the connection between the purpose and research questions. The viability of the scoping process is weighed against its breadth and quality in stage two. Studies are selected in an iterative manner at stage three. Step four involves extracting data. Steps five and six involve presenting results and considering how study findings may affect policy, practice, or research through a quantitative summary and a qualitative thematic analysis. Stakeholder consultation may be incorporated into the scoping study process at stage six as an essential knowledge translation component. (Tricco et al. 2016).

A data charting table was developed, this approach gives the reader a coherent and detailed explanation of the findings from the gathered articles, that is in line with the scoping review's objectives and questions, as key information of the sources such as Authors, year of publication, country of origin, aims, population and sample size, methodology, duration of the intervention, outcomes, key findings that relate to scoping review are charted and the table, Table 2 can be found in appendices.

4.2 Data search and selection

Data for this study were searched and identified by exploring articles related to non-pharmacological methods of alleviating sleep disturbances in AD and gathered using scientific databases such as CINAHL, Pubmed and MEDLINE, which are some of the widely used databases that contain articles related to healthcare and nursing and they were accessed through Metropolia University of Applied Science’s LibGuides.

Initially facet-analysis PICO method; Population, Intervention/exposure, Using MeSH (Medical Subject Headings), Comparison and Outcome was utilized to categorize and identify terms related to the study topic. The key terms related to the topic were identified and the articles were gathered using the following search terms: “Alzheimer’s disease” “Alzheimer*” “Alzheimer’s”, “Sleep disorder*”, “Sleep deprivation*”, “Sleep*”, “Sleep quality”, “Sleep hygiene*”, and “Sleep duration”, “Alleviate”, “Relieve”, “Wellbeing”, “Well-being”.

The selection of these keywords was based on their potential to address the research questions. The search was narrowed down by combining the search terms with the help of Boolean operators "AND" and "OR." Following are the used search phrases that were used to find articles on CINAHL, Pubmed and MEDLINE respectively: “Alzheimer’s disease OR Alzheimer* OR Alzheimer’s” AND “Sleep disorder* OR Sleep deprivation* OR Sleep* OR Sleep quality OR Sleep hygiene* OR Sleep duration” AND “Alleviate OR Relieve OR Wellbeing OR Well-being”.

The search was narrowed by establishing inclusion and exclusion criteria.

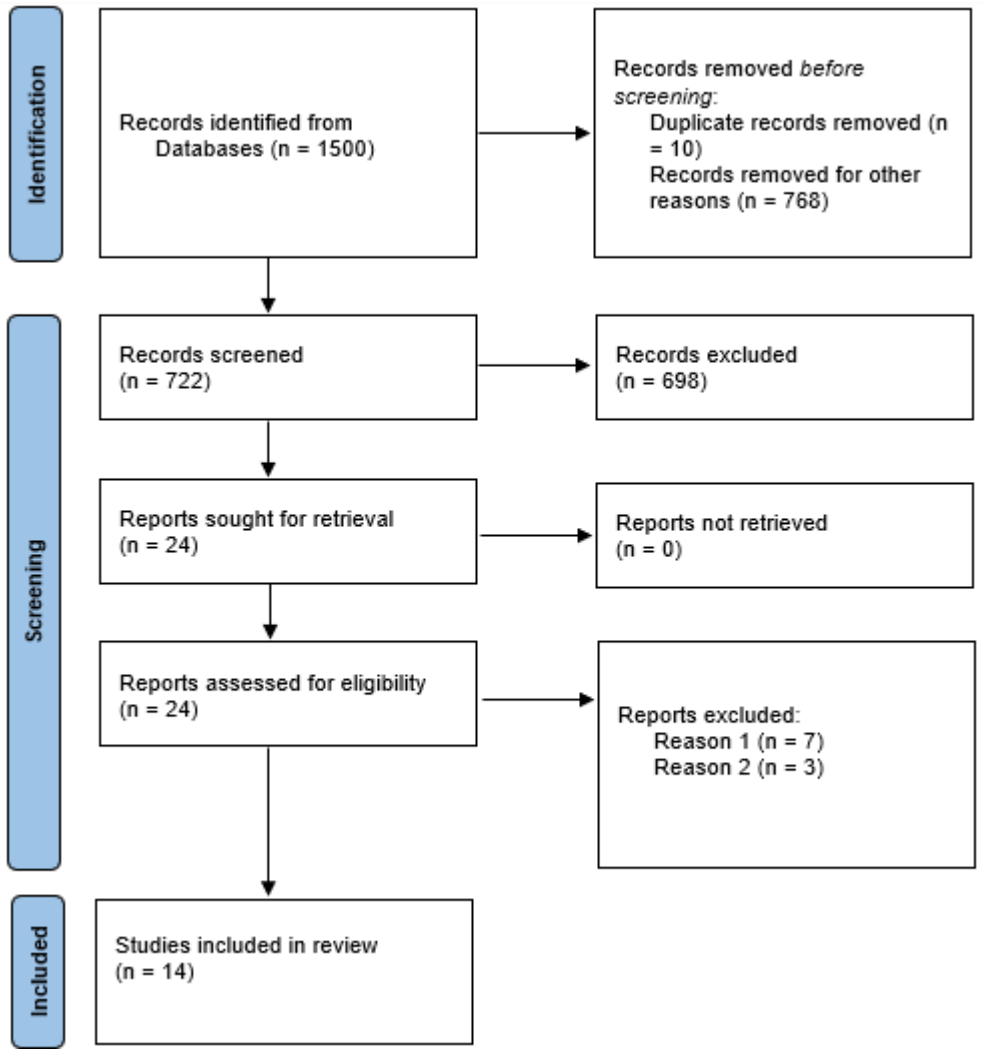
Table 1. The inclusion and exclusion criteria.

Inclusion	Exclusion
Articles published from 2000-2023	Articles published earlier than 2000
Articles with abstract	Articles without abstract
Peer reviewed articles	Non-peer reviewed articles
Full text articles	Articles without full text
People with > 60 years old	People < 60 years old
Relevant articles on the topic and research question	Non-relevant articles to the topic and research question
Patients with dementia, ADRD	Sleep disorders
Articles published in English language	Articles published in other languages

Inclusion criteria of the database search includes the following. The publication time frame for the article selection should preferably be within the five-year time frame, 2018-2023 but the time frame of ten-years, 2000-2023 were selected as they were considered and applicable in this review. All research publications included the abstract and full text, peer reviewed, related to the study topic, and answered the defined research questions, additionally, the published articles are written in English language. Similarly, the articles included results with people with AD, dementia or Alzheimer's Disease and Related Dementia (ADRD) who are over 60 years old that include sleep disturbances and non-pharmacological methods of alleviating it.

Articles were retrieved in two-step processors. In the first step relevant articles related to the topic were identified on reliable databases and were screened by title and abstract. In step

two, the retrieved potential articles were either included or excluded after full assessment of the articles. The Prisma chart below illustrates the process.



*Reason 1 – excluded due to failure to include outcomes about sleep disturbance assessment.

*Reason 2 – excluded due to insufficient information on non-pharmacological interventions.

Figure 1. Prisma chart

The database search outcomes seen in the Prisma chart above in figure 1, identifies n=1500 articles with n=722 being selected for further screening in relation to inclusion criteria, whereas n= 768 articles were removed down the process as they were not eligible as some recognized elements of exclusion criteria and some did not include full text articles. Additionally, n=10 was removed as they were duplicates. In the further screening phase n=698 more were excluded

while a total n=24 was retrieved and screened further. Out of the assessed eligible n=14 articles n=10 was excluded, as to its reasoning, Reason 1 – 7 articles excluded due to failure to include outcomes about sleep disturbance assessment and Reason 2 – 3 articles excluded due to insufficient information on non-pharmacological interventions. Overall, n=14 studies were included as shown in Table 2.

4.3 Data analysis method

In the scoping review, key concepts in specific research areas are mapped as it brings literature in disciplines together with impending evidence that addresses questions beyond experience of an intervention or effectiveness. In the process of a flowchart the number of studies should be identified, selected and reported, the review decision process should include clear details. Charting of the results should be done as the data extracted are logically summarized according to the questions of the review. As part of the process, a draft charting table was created, and it's essential to highlight the traits of the included studies as well as the most crucial information pertinent to the review question. A scoping review's outcomes are displayed as a map that logically and/or descriptively aligns the review's goals and parameters. (Peter, Godfrey, Khalil, McInerney, Parker, and Soares 2015: 142.)

5 Findings

It was determined that fourteen relevant studies contributed to the understanding of non-pharmacological methods of alleviating sleep disturbances in AD. Three of the studies utilized randomized control trials, one randomized controlled trial that included blinded assessors, two quantitative studies, two placebo-controlled studies one been randomized and the other single-blinded study, one case study, one case series, one experimental design and two systematic reviews and meta-analysis in which one is a randomized controlled trial. Various research methodologies collected data on non-pharmacological methods, types of light, intensity of lux, time duration of the participants exposed to light. The review determined that the sample size ranged from 3 to 648 individuals. The majority of the studies was carried out in the United States of America (USA) (9 studies), Japan (2), Austria, Brazil, China, South Korea, and Norway. A large number of the studies were conducted at clinics, while the majority of them took place in aged care or nursing homes. This scoping review identified the use of questionnaires and a particular device (an actigraphy device) for measuring and analyzing the primary concepts from the research questions.

5.1 Outcome measurements

The following outcome indicators are part of this review: evaluating and analyzing sleep patterns and daylight sleepiness using actigraphy devices, questionnaires and daysimeter. Nine out of Fourteen studies that assessed sleep disturbances utilized actigraphy (Ancoli-Israel et al. 2002; McCurry 2004; Dowling et al. 2005; McCurry et al. 2011; Friedman et al. 2012; Kim et al. 2017; Figueiro et al. 2019; Figuero et al. 2020; Fong et al. 2023), and almost most of these actigraphy was used together with sleep reports (McCurry et al. 2011; Friedman et al. 2012; Kim et al. 2017). The ActiwareTM Sleep Version 3.2 program was utilized to analyze the actigraphy data (Dowling et al., 2005:222). Meanwhile, Actiwatch 2, a product of Philips Respironics, Murrysville, PA, was utilized in three other studies (Kim et al., 2017:3; Figueiro et al., 2019:1759; Figuero et al., 2020:301). In a third study, the Micro-Mini Motionlogger actigraph was used to measure the actigraph data, and the Action4 software package was used to score the sleep and wakefulness using Cole and Kripke's sleep scoring system (McCurry et al., 2011:1395). The Action3 software package (McCurry 2004:374). The majority of actigraphy-based studies' main outcome variables were total waking time at night (McCurry et al. 2011:1395) and sleep efficiency (Dowling et al. 2005:225; Friedman et al. 2012:548; Figueiro et al. 2019:1760; Figuero et al. 2020:301). Additional secondary outcomes include the fragmentation index, wake-after-sleep onset (WASO), sleep onset percentage, sleep onset latency (SOL), sleep onset (SO), number of awakenings, total sleep time, time in bed (TIB, determined from sleep logs), estimated sleep parameters, actual sleep time, and daytime naps.

Questionnaires such as Epworth Sleepiness Scale (ESS) which contains sleep hygiene related behaviors and depressive symptoms and analyzes daytime sleepiness (Friedman et al. 2012: 548; Kim et al. 2017: 2). The GSAQ's first four questions were analyzed to determine how subjectively symptoms of daytime sleepiness and insomnia were measured (Friedman et al. 2012:548). The majority of studies verified sleep disturbances using the Pittsburgh Sleep Quality Index (PSQI), which has a worldwide score of greater than five points (Figueiro et al. 2014:1531; Kim et al. 2017:3; Figueiro et al. 2019:1759; Figuero et al. 2020:300; Kouzuki et al. 2020:165). PfefferInstrumental Activities Questionnaire (PIAQ), was used to assess instrumental deficits of patients such as warm up, muscular resistance, balance and motor coordination and aerobic fitness moreover Mini-Sleep Questionnaire (MSQ), to evaluate sleep disturbances (Nascimento et al. 2014:261). The frequency and severity of sleep disturbances scores that are linked to dementia are evaluated using the Neuropsychiatric Inventory, Nursing Home version (NPI-NH) (Sekiguchi et al. 2017:276).

A daysimeter is a device that measures activity levels and light exposure. It is worn at the height of the chest when the wearer is awake and placed next to the bed when they are asleep (Figueiro et al. 2014:1530; Figueiro et al. 2019:1759; Figuero et al. 2020:300). The light levels at the participants' eyes were measured using a spectroradiometer (model BTS256-E, Gigahertz-Optik, Amesbury, MA) (Figueiro et al. 2019:1759; Figuero et al. 2020:300). Bright Light ME (Over the Top Inc., Kobe, Japan) is a bright light therapy device that is positioned at eye level (Sekiguchi et al. 2017:277). Ancoli-Israel et al. (2002) described the Brite-Lite box (Apollo Light System, Orem, UT) as a light box that used cool-white fluorescent bulbs to provide light. For light distribution, use the SunRay light box (SunBox Company, Gaithersburg, MD) (McCurry 2011:1394). Timed BLT is administered by Litebook Edge (136 mm × 73 mm x 16 mm; Litebook Company Ltd., Alberta, Canada), which has 60 light-emitting diodes (LEDs) (Kim et al. 2017:3).

Among the studies that used light therapy to improve sleep disturbances, light therapy boxes were used with exposure of at least 2500 lux. The majority of these studies' intervention sessions were designed to last a minimum of 30 minutes (twice a day) and a maximum of 6 hours (2 hours thrice a day). In one study, the light intensity was set to 10,000 lux, and the subjects were exposed for two hours every day for two weeks. One of the studies used 10,000 lux for light intensity and used 2 hours exposure per day for 2 weeks. The early morning bright light exposure treatment did not improve sleep or the pattern of rest and activity in general, according to a study that used over 2500 lux and indoor light of about 150–200 lux for an hour. The findings also showed that the only participants who significantly and favorably responded to a brief one-hour light intervention were those with the most compromised rest-activity rhythm. (Fong and others, 2023:4). A 30-minute exposure to bright light above 2500 lux was shown in one study to be insufficient to improve sleep quality in elderly people with memory impairments (Friedman et al. 2012:549). According to two studies, blue-white light, one of which was timed, had an impact on sleep quality that persisted, but in the study by Kim et al. (2017:1) indicated that timed blue- attenuating light therapy had immediate lasting effects and was mostly effective on mild and moderate AD whereas in the other study it was stated that improvements were found in most severe AD (Figueiro et al. 2014:1534).

5.2 Evaluation of AD

Nearly all of the investigations (Ancoli-Israel et al. 2002:284; Friedman et al. 2012:548; Nascimento et al. 2014; Sekiguchi et al. 2017; Kim et al. 2017; Figueiro et al. 2019; Figuero et al. 2020:299) used the Mini-Mental State Examination (MMSE) to evaluate AD. The Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition (DSM-IV) (Figuero et al.

2014:1529; Figuero et al. 2020:299), the National Institute of Neurological and Communicative Disorders and Stroke - the Alzheimer's Disease and Related Disorders Association (NINCDS-ADRDA) (Dowling et al. 2005:221), TDAS, a modified version of the AD Assessment Scale-Cognitive Subscale, to evaluate cognitive function (Kouzuki et al. 2020:165), or diagnosis confirmation of AD from participants' primary physician (McCurry 2004:374; McCurry 2011:1394) are additional criteria. In order to verify if research participants had been diagnosed with AD, moderate cognitive impairment (MCI), other dementia, or diagnosable memory impairment, the AD Research Center referred individuals in one study (Friedman et al. 2012:546).

The data extracted are logically summarized into two tables below, Results table 1 (Table 3) and Results table 2 (Table 4). The author, the year, the study design, the participants, the setting and country, the non-pharmacological techniques, the intensity of light, the type of light, the time duration, and the outcomes are all listed in the Results Table 1. Similarly, Results Table 2 includes the following information: author, year, country, study design, study characteristics, intervention duration, follow-up times, study locations, sleep issues found, non-pharmacological approaches, and results.

5.3 Main Findings

5.3.1 Light Treatment Effectiveness in Managing Sleep Disturbances

Nine studies were included in this literature review that tested the impact of light treatment on sleep disturbances in individuals with AD. Our findings reveal a diverse range of results, with some studies reporting positive results while others did not demonstrate significant improvements in sleep quality or daytime alertness. For example, Ancoli-Israel et al.'s (2002) study of residents in nursing homes revealed no appreciable improvements in daytime alertness or overnight sleep after light therapy. On the other hand, Dowling et al. (2005) found that exposure to bright light in the morning was most beneficial for those with abnormal rest-activity cycles, but it did not result in improvements in all participants' sleep measurements.

Further insights come from a study by McCurry et al. (2011), where various treatments, including walking, light exposure, and combination treatment resulted in significant reductions in total wake time. But these interventions did not significantly improve the sleep disturbance index (SDI). Friedman et al. (2013) reported that brief morning bright light exposure did not significantly enhance sleep in older individuals with memory problems. Conversely, Figueiro

et al. (2014) tailored light delivery to reduce agitation and improve sleep in individuals with AD residing in long-term care facilities.

Sekiguchi et al. (2017) found that bright light therapy (BLT) was particularly effective for nocturnal sleep disturbances, especially among those in the mild to moderate stage of cognitive decline. According to Kim et al. (2017), individuals with mild to severe AD experienced improved subjective sleep quality and cognitive performance after receiving morning bright light treatment. Although, these interventions did not significantly affect objective sleep parameters. In another significant finding, Figueiro et al. (2019) demonstrated that a lighting intervention tailored to entrain the circadian system led to improvements in sleep, mood, and behavior among patients with dementia living in controlled environments. Additionally, a separate investigation by Figueiro et al. (2020) noted improvements in sleep quality, with some participants experiencing significant reductions in total wake time and improvements in sleep onset latency. Notably, this study did not find significant effects on daytime naps. Overall, the results from these studies provide an intricate understanding of the effects of light treatments on sleep disturbances in individuals with AD. In the same way, they showed the need for further research to elucidate the underlying mechanisms and optimize treatment approaches.

5.3.2 Systematic Reviews on Light Treatment

Systematic reviews play a crucial role in synthesizing and summarizing the existing body of research, offering insights into the overall effectiveness of light treatment for managing sleep disturbances in individuals with AD. Fong et al. (2023) and He et al. (2023) have conducted two systematic reviews that offer thorough evaluations of the effects of light therapy on sleep and associated outcomes.

A systematic review by Fong et al. (2023) examined several studies looking at how light therapy affects people with dementia. Their findings suggested that light therapy was associated with a reduction in the number of nighttime awakenings, indicating its potential in enhancing sleep continuity. However, this review did not find a significant improvement in wake after sleep initiation or in addressing symptoms of agitation and depression among those with dementia. Additionally, it is important to note that this review highlighted a notable gap in the literature concerning the long-term consequences of light treatment.

In the systematic review conducted by He et al. (2023), a variety of interventions, including light therapy were evaluated for their impact on sleep disturbances in dementia. Their review

revealed positive findings related to light therapy. Multiple studies included in this systematic review demonstrated improvements in sleep efficiency both before and after light treatment. Notably, the combined analysis indicated a significant reduction in sleep disturbances, emphasizing the potential benefits of light therapy in improving sleep quality for dementia.

5.3.3 Behavioral Strategies, Physical Activity, and Aroma bath Salt Effectiveness in Managing Sleep Disturbances

Behavioral strategies to address sleep disturbances in individuals with AD were introduced by McCurry's 2004 study. The results of this intervention were encouraging, as indicated by post-test actigraphic improvements. Participants demonstrated enhanced sleep quantity and sleep efficiency, reduced nighttime awakenings, and less daytime sleep. Additionally, subjective sleep ratings improved, with one subject maintaining these gains at the 6-month follow-up. This intervention highlighted the potential effectiveness of non-pharmacological approaches, such as behavioral strategies, in improving sleep patterns in individuals with AD, although the complexity of nighttime behavioral disturbances in this population is noteworthy.

A study involving walking, exposure to light, and a combination of these interventions was carried out on an elderly female participant with AD by McCurry et al. (2011). At the post-test assessment, the total wake time significantly improved as a result of these interventions, according to the results. Effect sizes further indicated the magnitude of these improvements, particularly in actigraphic sleep percentage. Interestingly, adherence to the walking and light exposure recommendations played a crucial role in the observed improvements. Participants who adhered to these recommendations at a rate of four days per week experienced significantly less total wake time and improved sleep efficiency. These findings underscore the potential benefits of regular walking and light exposure in managing sleep disturbances among individuals with AD.

Physical exercise as an intervention for people with AD was the subject of a study done by Nascimento et al. (2014). The results were promising, as the study highlighted the significance of Mini-Mental State Examination (MMSE) scores as predictors. MMSE scores were associated with improvements in instrumental activities performance and reductions in sleep-related disturbances. This study suggested that a six-month physical exercise intervention had positive effects on evaluated variables for both AD and Parkinson's Disease (PD) patients. The findings indicate that physical exercise may offer a valuable approach to address sleep disturbances and cognitive function in individuals with AD, suggesting its potential as a non-pharmacological intervention.

To determine the efficacy of aroma bath salt interventions, Kouzuki et al. (2020) studied people with AD who also had mild cognitive impairment (MCI). Even though the aroma bath salt intervention did not result in statistically significant overall improvements in cognitive and sleep-related assessments, the correlations between TDAS scores and specific aspects of sleep quality in the 0.1% group that were found indicate that more research may be necessary to fully explore the potential advantages of this intervention for people with AD. The findings highlight the difficulty of treating cognitive and sleep-related problems with interventions and point to the need for additional study in this field.

These findings reflect the diverse range of interventions and their varying impacts on cognitive function, sleep quality, and behavioral disturbances in individuals with AD and related conditions. Although some interventions demonstrated positive outcomes, others showed limited or mixed results, emphasizing the complexity of managing sleep disturbances and cognitive function in this population. Further research may help refine and optimize these interventions for better outcomes.

Table 3. Results 1: What non-pharmacological methods have been explored to alleviate sleep disturbances in individuals with AD?

	Author and Year	Study Design	Participants, Setting and Country	Non-Pharmacological methods	Intensity of Lux	Type of light	Time duration	Outcomes (measurement)	Summary of Results on Sleep
1	Ancoli-Israel et al. 2002	Randomized controlled trial	- 77 participants - Nursing home - United States of America (USA)	light therapy	-2500 lux -2500 lux -less than 50 lux red light	-morning Bright light -evening Bright light -evening Dim light	-2 hours -2 hours -2 hours	Actillume recorders	Across all therapy groups, there were no improvements in either daytime alertness or nighttime sleep. No improvements were found in the quality of nighttime sleep or daytime alertness. Morning exposure to bright light caused a delay in the acrophase of the activity rhythm and led to an improvement in circadian activity rhythm.
2	McCurry et al. 2004	Case study	- 3 participants - in-home based -USA	Behavioral strategies	not applicable	not applicable	not applicable	-Actillume (wrist-movement recorder) -Action3 software	After the post-test, positive changes were detected in various sleep aspects, including sleep duration and efficiency, reduced nighttime awakenings, and decreased daytime sleep. Subjective sleep ratings also showed improvement. One subject sustained these improvements even

									during the 6-month follow-up. The subjects exhibited a broad range of sleep-related issues and varied in the behavioral strategies employed by their family caregivers. This diversity underscores the intricate nature of nighttime behavioral disturbances in individuals with AD.
3	Dowling et al. 2005	Randomized placebo-controlled	- 46 participants - Nursing home and hospital - USA	light therapy	- 2500 lux in gaze direction - Control group - indoor light (150–200 lux)	- bright light exposure - indoor light	One hour for both groups	Actigraphy	While notable enhancements were observed in individuals with disrupted rest-activity rhythms, compared to control participants, morning bright light exposure did not provide a complete improvement in sleep-related measurements or the overall rest-activity patterns.The results imply that the brief (one-hour) light intervention only produced a substantial and positive response in those whose rest-activity cycles were most seriously disrupted.
4	McCurry et al.	Randomized, controll	- 132 participants and their in-	- Walking - light	- 2500 lux		- 30 minutes -1 hour	- wrist actigraphy - Sleep Disorders	With moderate effect sizes ranging from 0.51 to 0.63, participants in the walking,

	2011	ed trial with blinde assess ors	home caregivers - in-home based - USA	- combinatio n treatment (walking, light, and guided sleep education)		- SunRay light box (light intervention)	- does not specify the exact time duration for the combination treatment involving walking, light exposure, and guided sleep education.	Inventory	light, and combination therapy groups had substantially greater post-test improvements in total waking time. However, there were no significant improvements in the SDI. In comparison to individuals who adhered less to the walking and light exposure requirements (at least four days per week), those who adhered better to the recommendations had considerably lower total waking time and improved sleep efficiency at the posttest.In terms of sleep outcomes at six months, there were no significant group differences.
5	Friedma n et al. 2012	Rando mized controll ed trial	- 54 participants and their caregivers - in-home based - USA	light therapy	- 4,200 ± 1,600 lux (in “bright” condition) -90 ± 96 lux (in “dim” condition)	- bright condition (full spectrum white light - dim condition (filtered or dim light)	30 minutes for both conditions	- wrist actigraphy - sleep reports - Epworth Sleepiness Scale	The findings indicate that a short, 30-minute exposure to morning bright light was insufficient to enhance sleep quality in care recipients with memory issues or their caregivers.

6	Figueiro et al. 2014	Quantitative	-14 participants - Nursing home - USA	light therapy	It doesn't specify whether the lux levels mentioned are solely from the floor lamps used in the lighting intervention or if they also include the lux levels of the specific light sources used in the treatments.	- “bluish-white” light - “yellowish-white” light	30 minutes for both types of light	- Daysimeter - Pittsburgh Sleep Quality Index - Minimum Data Set Activities of Daily Living Scale - Cornell Scale for Depression in Dementia - Cohen-Mansfield Agitation Inventory	The lighting intervention had a significant positive impact ($p \leq 0.05$) on various sleep-related measures. Along with an improvement in overall duration of sleep and efficiency, it resulted in a reduction in overall sleep disturbances as measured by the Pittsburgh Sleep Quality Index. Furthermore, the intervention improved the alignment between light-dark cycles and rest-activity patterns, indicating enhanced circadian entrainment, as demonstrated by an increased phasor magnitude. Additionally, the lighting intervention resulted in significant reductions ($p \leq 0.05$) in depression scores according to the Cornell Scale for Depression in Dementia and in agitation scores from the Cohen-Mansfield Agitation Inventory.
7	Nascimento et al. 2014	Quantitative	- 35 participants - it doesn't explicitly mention	-warm up -muscular resistance -balance and motor	Not applicable	Not applicable	1 hour session per week of a multimodal exercise	- Pfeffer Instrumental Activities Questionnaire - Mini-Sleep Questionnaire	The findings indicated that higher MMSE scores can significantly predict better performance in instrumental activities

			whether the treatment in this study was conducted in a nursing home, in-home, or any specific setting - Brazil	coordination			program for 6 months	- chest pulsometer	(R2=0.12; p<0.001) and reduced sleep-related disturbances (R2=0.35; p<0.001). The results demonstrate that a six-month physical exercise intervention had a positive impact on the assessed variables for both PD and AD patients.
8	Sekiguchi et al. 2017	Case series	- 17 participants - Nursing home - Japan	light therapy	5000 lux	Bright light therapy	1h/day in the morning from 0900 to 1000	Neuropsychiatric Inventory-Nursing Home tool	BLT was beneficial for AD patients with a Mini-Mental State Examination (MMSE) score of 10 or higher, while it did not appear to be effective for individuals in the severe stages of AD.
9	Kim et al 2017	Single-blind, placebo controlled study with a between-within design	- 25 participants - in-home - South Korea	light therapy	750 lux	Blue-enriched white light	Between 9 and 10 h	-Pittsburgh Sleep Quality Index -Mini-Mental State Examination -Trail Making Test -Digit Span Test Forward -Digit Span Test Backward - Cornell Scale for Depression in Dementia	Between the baseline and the 4-week follow-up, the TG saw a considerably larger drop in PSQI score than the CG.Objective sleep measures did not significantly alter over time, however the 4-week follow-up showed a noteworthy shift in cognitive function (MMSE-KC) scores.

								- Visual Analogue Scale -Global Vgor - VAS-Global Affect - Neuropsychiatric Inventory Questionnaire - Actigraphy - Zarit Burden Interview - Neuropsychiatric Inventory Questionnaire	
10	Figueiro et al. 2019	Randomized Clinical Trial	- 46 participants - nursing home - USA	light therapy	- either 600 lux of 5000 K correlated color temperature (CCT) or 550 lux of 7000 K CCT - either 110 lux of 2700 K CCT or 110 lux of 2000 K CCT	- active lighting intervention -control Intervention	1 hour for both types of light	- Actigraphy - Daysimeter - Pittsburgh Sleep Quality Index - Cornell Scale for Depression - Cohen-Mansfield Agitation Inventory -Minimum Data Set - Activities of Daily Living Scale	The active intervention led to a significant improvement in the Pittsburgh Sleep Quality Index (PSQI) scores when compared to the active baseline and control intervention. After the active intervention, the mean score was 6.67 ± 0.48, at the active baseline it was 10.30 ± 0.40, and following the control intervention it was 8.41 ± 0.47. Additionally, comparing the active intervention to the control intervention, the former produced considerably

									larger changes in intradaily variability.
11	Kouzuki et al. 2020	Randomized controlled trial	- 35 participants - in-home based - Japan	aroma bath salt	Not applicable	Not applicable	- The aroma oil/bath salt was added to the bath, and the subjects were asked to stay in the bathroom for ≥10 min.	- Pittsburgh Sleep Quality Index - Test of Detection of Attention - Odor Stick Identification Test - Japanese	The findings of the study indicated that over a 24-week duration, the use of aroma bath salts at concentrations of 0.1%, 0.5%, or 1% did not lead to enhancements in cognitive function, olfactory function, or sleep quality.
12	Figuero et al. 2020	Experimental design	- 47 participants - senior care facility - USA	light therapy	not stated	All-day lighting intervention	1 hour	- Actigraphy - Spectroradiometer - Daysmeter	The Pittsburgh Sleep Quality Index scores significantly improved as a result of the intervention. Additionally, better sleep efficiency, as measured by actigraph data, was observed. The intervention produced statistically significant decreases in scores on the Cohen-Mansfield Agitation Inventory and the Cornell Scale for Depression in Dementia.
13	Fong et al. 2023	Systematic review and meta-analysi	- 648 participants -nursing care homes and in-home based	light therapy	- 2500 lux - 10,000 lux - 1000 lux - 1000 lux	- morning - evening bright - dim - ambient	30 minutes to 8 hours	- Actigraphy - Dutch behavior observation scale for intramural	Light therapy can be beneficial for individuals with dementia who experience sleep disturbances, as it can reduce the frequency of

		s of randomized controlled trials	- Hong Kong, China		- 1800 lux - 4200 lux	- standard - low-intensity light		psychogeriatrics - Actillume - Cornell Scale for Depression in Dementia - Cohen-Mansfield Agitation Inventory - Neuropsychiatric Inventory-Nursing Home tool	nighttime awakenings. However, it may not have a significant impact on minimizing the time spent awake after initially falling asleep, or on alleviating symptoms of agitation and depression. It's important to note that the long-term effects of light treatment remain uncertain due to a lack of conclusive evidence.

14	He et al. 2023	Systematic review and meta-analysis	-530 participants - Nursing homes, long-term care facilities, community, and home intervention - USA, Norway and Austria	Pet-type robotic seal (PARO), light therapy, and slow stroke back mass (SSBM).	2500 lux	Full spectrum light	30 minutes to 1 hour	- Sleep Disorder Inventor - Sleep apnea score	Improved sleep disturbances were seen both before and after light treatment, according to three studies. The combined two scales' impact size was -0.54, which is significant (z = -2.766, p = 0.006) and indicates that light therapy improves sleep disturbance. In PlwD, better sleep efficiency was shown both before and after light treatment, according to two studies. This study therefore demonstrated that PARO increases the amount of time that people with depression spend sleeping at night and that there is inconclusive evidence on the effectiveness of light treatment and SSBM in decreasing depression, nighttime sleep, sleep disturbance, and efficiency.

5.4 Potential gaps for future investigations

Research in the field of non-pharmacological interventions for alleviating sleep disturbances in AD patients presents several notable gaps, each with its unique implications for understanding and improving care. One critical area requiring further exploration involves the long-term effects of these interventions. There is a notable gap in comprehending the sustained benefits and potential drawbacks of these interventions when applied over extended periods. Investigating the long-term impacts on sleep patterns, cognitive function, and overall well-being in AD patients could yield valuable insights. Additionally, the nature of sleep disturbances in AD is indeed an important aspect that can be considered as a potential gap in research. Understanding the specific characteristics and underlying mechanisms of sleep disturbances in AD patients can provide valuable insights for developing targeted non-pharmacological interventions. This knowledge can help researchers and healthcare professionals tailor interventions to address the unique nature of sleep disturbances in AD, potentially leading to more effective treatments.

Comparative effectiveness studies are required to shed light on the varying impacts of different non-pharmacological interventions. For instance, a more in-depth investigation into whether interventions like bright light therapy are more or less effective than alternatives such as physical exercise or aroma bath salts in improving sleep and cognitive function among AD patients is warranted. Moreover, personalized approaches in non-pharmacological interventions have not been adequately addressed in current research. Individual variability among AD patients, influenced by factors like disease severity, age, and genetics, may significantly impact the suitability and effectiveness of specific interventions. Therefore, further exploration of personalized treatment plans based on these factors is essential. The potential effects of combined non-pharmacological interventions, such as exercise and light therapy, require more in-depth investigation. Research in this area can help determine whether combined interventions offer superior outcomes compared to single interventions, enhancing our understanding of the most effective treatment strategies for AD patients.

While many studies have focused on specific settings, sample sizes, and populations, such as nursing homes and patients with mild to moderate AD, exploring the applicability and effectiveness of these interventions in diverse settings, larger samples, and among various AD populations, including those living at home, is necessary. A more comprehensive understanding of where these interventions can be effectively applied is vital. In addition, standardization of outcome measures is essential for facilitating direct comparisons between studies. While various outcome measures, such as actigraphy, questionnaires, and daysimeters, have been employed, harmonizing these measures and defining clear benchmarks for improvement can contribute to more robust and conclusive research outcomes. Moreover, involving family members and caregivers in non-pharmacological interventions and assessing their impact on the well-being of AD patients is an area that is ready and suitable for further research. Understanding how caregiver support can enhance the effectiveness of these interventions is of great value, considering the vital role that caregivers play in the lives of AD patients. Lastly, the research gap in studying the quality of life and caregiver burden of AD patients exists because it's crucial to fully grasp how sleep problems and treatments affect both patients and their caregivers. While many studies focus on medical aspects, we need more research on how these issues impact the daily lives and well-being of AD patients and those who care for them. This helps us provide more comprehensive and effective care.

Addressing these research gaps will not only enhance our understanding of non-pharmacological interventions for AD-related sleep disturbances but also contribute to more effective, personalized, and efficient treatment for this population. By addressing these gaps, researchers can refine existing methods, develop new strategies, and tailor treatments to individual needs. It can lead to improved patient outcomes. Moreover, the involvement of family members and caregivers in interventions acknowledges the important role they play in the care of AD patients and can lead to strategies that better support both patients and their caregivers.

Table 4. Results 2: What are the potential gaps for future investigations?

	Author Year Country	**Study design**	**Study characteristics (sample size, gender, age)**	**Duration of the intervention**	**Follow up periods**	**Sleep problems identified**	**Non pharmacological methods**	**Quality of life and caregiver burden**
1	Ancoli-Israel et al. 2002 USA	Randomized controlled trial	-77 nursing home residents. -58 women, 19 men. -Mean age 86 years	18 days	No follow up periods mentioned	Not identified	light therapy	It did not specifically assess or discuss the quality of life and caregiver burden.
2	McCurry et al. 2004 USA	Case studies	-3 participants. -2 women, 1 man. -Mean age 81 years.	2 months	Yes. 6-month follow up	Nightmares, nighttime wandering, sleeping excessively during the day, never slept more than 1 h at a time at night, getting up frequently, and nighttime awakenings	behavioral strategies	It did not specifically assess or discuss the quality of life and caregiver burden.
3	Dowling et al.	Randomized	-46 participants. Gender- not mentioned	12 weeks	No follow up periods	Not identified	light therapy	It did not specifically assess or discuss the quality of life and caregiver burden.

	2005 USA	placebo-controlled	-Mean age 84 years		mentioned			
4	McCurry et al. 2011 USA	Randomized, controlled trial with blinded assessors	-132 participants were randomized and 108 were analyzed. -All participants are female. -Ages between 80-82 years old.	2 months	Yes. 6-month follow up		- Walking - light -combination treatment (walking, light, and guided sleep education)	It failed to address or evaluate quality of life or caregiver burden in particular. But only mentions caregiver satisfaction and their perceptions of the treatment conditions but does not explicitly discuss quality of life or caregiver burden.
5	Friedman et al. 2012 USA	Randomized controlled trial	54 caregiver-care recipient dyads. 23 female, 31 male. -Mean age: 78 years	2 weeks	No follow up periods mentioned	Not identified	light therapy	It did not specifically assess or discuss the quality of life and caregiver burden.
6	Figueiro et al. 2014 USA	Quantitative	14 participants. -9 female, 5 male. -Mean age: 87 years.	4 weeks	No follow up periods mentioned	Not identified	light therapy	IIt did not specifically assess or discuss the quality of life and caregiver burden.

7	Nascimento et al. 2014 Brazil	Quantitative	-35 participants -training group: 5 male, 9 female. -Mean age: 77 years control group: 6 male, 10 female. -Mean age - 78 years	6 months	No follow ups	Not identified	-warm up -muscular resistance -balance and motor coordination	It did not specifically assess or discuss the quality of life and caregiver burden.
8	Sekiguchi et al. 2017 Japan	Case series	- 17 participants: (AD) (n = 8), vascular dementia (n = 4), and dementia with Lewy bodies (n = 5). -Number of Female Participants with AD: 3. The age range is 71-78 years old. -Number of Male Participants AD: 5. The age range is 77-84 years old.	2 weeks	No follow up periods mentioned.	Residual nocturnal sleep disturbance and the frequency and severity of sleep disturbance scores on the Neuropsychiatric Inventory, Nursing Home version (NPI-NH)46 had a product ≥4;28 and (ii) the patient's care burden score was ≥3 (higher than a moderate grade).	light therapy	It did not specifically assess or discuss the quality of life and caregiver burden.
9	Kim et al 2017	Randomized controlled trial	25 participants with mild and moderate AD	2 weeks	4 weeks after the intervention	A Pittsburgh Sleep Quality Index (PSQI) score of five or above confirms	light therapy	ZBI-K scores indicated a considerable decrease in caregiver burden, at the 4-week follow-up in the treatment group (TG). This

	South Korea		-The average age for the TG (Treatment Group) is approximately 77 years. -The average age for the CG (Control Group) is approximately 79 years. -In the TG, there are 2 males and 12 females. -In the CG, there are 5 males and 6 females.			a sleep disturbance. Difficulty initiating sleep (DIS), difficulty maintaining sleep (DMS), and early morning awakening (EMA) for 3 or more days per week.		suggests a positive effect on caregiver burden, which indirectly impacts the quality of life for caregivers and, by extension, the care recipients. While the data presented doesn't explicitly address "quality of life," it provides insights into factors that can influence it, such as sleep quality, cognitive function, and caregiver burden. (The Korean versions of the Neuropsychiatric Inventory Questionnaire (distress) and the Zarit Burden Interview (ZBI-K) were used to measure the burden of caregiver (KNPI-Qd))
10	Figueiro et al. 2019 USA	A Randomized Clinical Trial	-46 participants -30 female, 16 male. -Mean age of female 85 years - Mean age of male 83 years.	14 week	No follow up periods mentioned.	Not identified	light therapy	It did not specifically assess or discuss the quality of life and caregiver burden.

11	Kouzuki et al. 2020 Japan	Randomized controlled trial	35 participants (AD 10, mild cognitive impairment: 25) Age range: 75- 84 years old Male: 11 Female: 14	24 weeks	No follow up periods mentioned.	The Pittsburgh Sleep Quality Index (PSQI) scores range from 3-4. (Scores of 3-4 suggest that the individual experienced minor sleep disturbances during the assessed)	Aroma oil as bath salt.	It did not specifically assess or discuss the quality of life and caregiver burden.
12	Figuero et al. 2020 USA	Experimental design	47 participants Female-27, Male-20 Female, Mean age: 89 years Male: Mean age: 81 years.	25 weeks	No follow up periods mentioned.	Global scores >5 points indicate sleep disturbances.	light therapy	It did not specifically assess or discuss the quality of life and caregiver burden.

13	Fong et al. 2023 Hong Kong, China	Systematic review and meta-analysis of randomized controlled trials	648 participants 398 female and 546 male. Age range between 69-89 years.	2 weeks to 24 weeks	No follow up mentioned	Not identified	light therapy	It did not specifically assess or discuss the quality of life and caregiver burden.
14	He et al. 2023 USA, Norway and Austria	Systematic review and meta-analysis	530 participants Gender unclear except one study Age range between 83- 36 years.	-not mentioned	No follow up mentioned	Not identified	- Pet-type robotic seal - light therapy - slow stroke back mass	It did not specifically assess or discuss the quality of life and caregiver burden.

6 Discussion

Critical insights into the intricate relationship between circadian rhythms and sleep problems in individuals with AD can be gained from the research findings on light therapy. More specifically, light therapy has proven to be an effective method of restoring circadian regulation when there were significant disruptions. This efficacy highlights the significance of circadian rhythm synchronization in treating sleep-related conditions in this population, especially with regard to the function of the suprachiasmatic nucleus (SCN).

The outcomes of many trials examining the impact of light treatment on sleep disturbances in individuals with AD showed notable differences. Ancoli-Israel et al. (2002) for instance, discovered no discernible effects on residents of nursing homes' nocturnal sleep or waking alertness during the day, indicating that their circadian rhythms were not perfectly synchronized. This emphasizes the need for additional research to enhance therapeutic strategies and attain better synchronization with circadian rhythms, encompassing the SCN, the central circadian pacemaker.

On the other hand, Dowling et al. (2005) found that people with irregular rest-activity rhythms benefited most from bright light exposure in the morning. This finding supports the idea of circadian rhythm synchronization and the function of the SCN, suggesting that managing circadian rhythms may be a useful strategy for treating sleep disturbances.

The study by McCurry et al. (2011) investigated a number of therapies, including exposure to light, and found that they significantly shortened wake times overall. The reduced wake time indicates a partial synchronization with circadian rhythms, suggesting a beneficial impact on certain aspects of sleep, even though these interventions did not significantly improve the sleep disturbance index (SDI). The SCN is critical to this synchronization.

Friedman et al. (2013), on the other hand, discovered that older adults with memory impairments did not significantly improve their sleep after a brief morning exposure to bright light, indicating that circadian rhythm synchronization was ineffective in this specific population and may also be related to SCN function.

In order to lessen agitation and improve sleep in people with AD, Figueiro et al. (2014) tailored light delivery in long-term care facilities. By influencing the SCN, this method

probably enhanced synchronization with the circadian system and illustrated the possible advantages of accomplishing this synchronization.

Bright light therapy (BLT), according to a 2017 study by Sekiguchi et al., is effective in treating nocturnal sleep disturbances, particularly in people who have mild to moderate cognitive decline. The important function of the SCN and circadian rhythm regulation is further supported by BLT's demonstration of synchronization with the circadian system and enhancements in sleep quality.

The disparities in results between the reviewed studies must be acknowledged; these variations can be linked to individual differences in disruptions of circadian rhythms and possible involvement of the SCN. The idea that the stage of cognitive decline may affect the efficacy of light therapy is supported by studies such as Kim et al. (2017), which focused on people with mild to moderate cognitive decline and showed varying degrees of success in improving sleep quality. In order to effectively customize non-pharmacological interventions, it is imperative to comprehend these individual differences and their relationship to disruptions of the circadian rhythm, potentially involving the SCN.

These results highlight how important it is to comprehend the behavioral factors that affect sleep patterns and general well-being in AD patients receiving non-pharmacological interventions. The Theory of Planned Behavior (TPB) states that intentions and perceived behavioral control have an impact on how a behavior is performed. (Ajzen 1991: 185). In assessing the efficacy of interventions such as those developed by McCurry (2004), McCurry et al. (2011), Nascimento et al. (2014), and Kouzuki et al. (2020), it is imperative to take into account the potential influence of participants' intentions and perceptions of behavioral control on the results.

One example of how perceived behavioral control may have an impact on the effectiveness of an intervention is demonstrated by the fact that following guidelines for regular walking and light exposure, as demonstrated in McCurry et al.'s 2011 study, was critical to improving sleep patterns. The correlations discovered in Kouzuki et al. (2020) study suggest that aroma bath salt interventions may improve the quality of sleep, but more investigation may be required to completely explore these benefits, with a focus on the importance of intentions. These results demonstrate how behavioral strategies, intentions, and perceived control interact to manage sleep disturbances in AD patients, highlighting the importance of TPB in comprehending and improving non-pharmacological interventions.

Understanding how non-pharmacological treatments synchronize with circadian rhythms requires looking into the long-term effects of these interventions in AD patients. It highlights how crucial circadian rhythms are for controlling sleep cycles and general wellbeing. Examining long-term benefits and possible risks can help determine whether these interventions are beneficial in maintaining circadian rhythm regulation. This information is crucial for improving treatment strategies and improving AD patients' long-term wellbeing.

Comprehending the distinct attributes and fundamental mechanisms of sleep disruptions in individuals with AD is imperative. These revelations have a direct bearing on how the SCN controls sleep-wake cycles. Examining the type of sleep disruptions can reveal important details about how AD patients' SCNs are impacted. To improve sleep patterns, non-pharmacological interventions that are tailored to the particulars of these disturbances can be very successful. This strategy might lessen the effects of SCN dysfunction and increase the treatments' overall efficacy.

A valuable way to understand the Theory of Planned Behavior (TPB) is through personalized approaches in non-pharmacological interventions and comparative effectiveness studies. TPB places a strong emphasis on how intentions and perceived behavioral control affect actions. A foundation for comprehending how intentions and perceived control may differ among AD patients when choosing particular treatments is provided by comparative studies evaluating the efficacy of various interventions. Investigating individualized treatment regimens based on variables such as age, genetics, and the severity of the disease is consistent with TPB since it acknowledges the influence of individual variability on the appropriateness and efficacy of interventions. Non-pharmacological treatments that are more individualized and effective may result from this personalized approach.

All things considered, the information gathered from the studies that have been reviewed offers a nuanced picture of how well light therapy works to treat sleep disorders in AD patients. The disparity in results emphasizes the necessity of more research to maximize treatment modalities while taking the SCN's function and circadian rhythm regulation into account. In this optimization process, variables like individual differences, the stage of cognitive decline, and the long-term effects of interventions should all be taken into account. The relevance of maintaining synchronization with circadian rhythms to preserve homeostasis and general health in individuals with AD is highlighted by the connection between the need for optimization and the understanding and treatment of circadian rhythm abnormalities, as proposed by circadian rhythm theory and the SCN.

6.1 Ethics and validity

Research must adhere to the principles of responsible research conduct in order for its findings to be credible and reliable. It is the duty of the scientific community as a whole as well as of individual researchers to conduct research responsibly (University of Helsinki). Finland has a system for self-regulation that is founded on national guidelines for the detection and investigation of research infractions related to responsible behavior. These rules were initially published in 1994. The openness and transparency of science, as well as the mutual trust between researchers and research organizations, serve as its foundation in addition to the internal rules within the scientific community. In democracies similar to Finland's, the self-regulation model functions effectively. The Finnish National Board on Research Integrity TENK's 2023 guidelines for managing alleged violations of research integrity and the Finnish code of conduct for research integrity serve as the foundation for the definition of research integrity in Finland and the investigation of cases of alleged violations. (Tenk 2023.)

The proposed literature review is to be conducted by ensuring the review's ethical reliability and validity by considering characteristics of honesty, meticulousness, and accuracy at every level of good ethical research (Gerrish & Lacey & Cormack 2010). This study is to maintain autonomy keeping in mind that every individual matters and has the right to be treated with respect, therefore respecting the person's decision entails respecting them as a person. Integrity and avoiding any type of research misconduct shall be upheld in order to pursue high standards (Gerrish, Lacey, and Cormack 2010: 28).

We shall use approved and ethical studies and data collecting techniques. Plagiarism to be avoided and honesty shall be upheld by acknowledging and honoring the contributions of the necessary authors and by making sure that no permits for further research are required as this is only a review of the literature (Wager and Wiffen 2011). Both authors' independent reviews of the review will be used to determine reliability, The thesis supervisor will enhance the validity. The validity and reliability of the results will be taken into account when comparing the results from various data sources. The databases being used in this review are regarded as reliable and approved by Metropolia University of Applied Sciences.

6.2 Conclusions

In this scoping literature review, we explored various non-pharmacological methods aimed at alleviating sleep disturbances in individuals with AD. The studies encompass a wide array of non-pharmacological interventions, including light therapy, aroma bath salts, circadian-effective lighting, exercise, and more. This means that the variety of non-pharmacological interventions explored in the studies represents a continuous effort to develop comprehensive strategies for addressing the symptoms associated with AD. Consequently, these interventions have demonstrated positive effects on sleep parameters, such as improved sleep quality, increased sleep duration, and enhanced sleep efficiency. The findings suggest that non-pharmacological strategies hold promise for addressing the sleep disturbances commonly experienced by individuals with AD. However, it's important to note that the primary focus of these studies centers on sleep and related outcomes. They do not directly assess or report on the quality of life and caregiver burden. While improved sleep and reduced behavioral symptoms may indirectly contribute to enhanced quality of life and reduced caregiver burden, these aspects are not the central focus of the investigations. Consequently, these studies collectively underscore the need for further research, particularly larger-scale randomized controlled trials, to gain a better understanding of the long-term effects of these interventions. Additionally, it is recommended that future studies focus on the promising field of integrating numerous non-pharmacological sleep treatment methods.

These studies provide insightful information on the possibility of non-pharmacological therapies for treating sleep disturbances and associated symptoms in people who have dementia. While further research is necessary to comprehensively assess their impact, these findings contribute to the ongoing efforts aimed at enhancing the well-being and care of patients with AD.

6.3 Limitations and Recommendation

The limitations of the 14 studies on non-pharmacological methods to alleviate sleep disturbances in AD can vary from one study to another. One common issue is that many studies use small sample sizes, making it uncertain whether the findings can apply to a larger and more varied group of AD patients. To address this limitation, future research should emphasize the use of larger and more varied samples to bolster the validity and applicability of results.

Furthermore, numerous studies suffer from relatively short intervention periods, which might not fully capture the long-term impacts or sustainability of the interventions. The absence of extended follow-up assessments leaves uncertainties regarding the lasting benefits and potential drawbacks of these interventions. Thus, it is advisable for future studies to implement longer follow-up periods to assess the sustained effects on sleep patterns, cognitive function, and overall well-being in AD patients.

Another noticeable shortcoming is the absence of comparative effectiveness studies, this hampers the determination of the most effective non-pharmacological interventions for improving sleep and cognitive function in AD patients. Consequently, it is crucial for future research to focus on comparative studies, thus addressing this pivotal gap in our knowledge.

Moreover, a significant limitation is the inadequate individualization of interventions in many studies. Individual variability among AD patients, shaped by factors like disease severity, age, and genetics, is often not sufficiently considered. This underscores the importance of exploring personalized treatment plans tailored to the unique needs of each patient.

A vital aspect of the research gap lies in the unexplored territory of combined non-pharmacological interventions and their potential synergistic effects. There is a pressing need for comprehensive research to delve into the effects of using multiple interventions in combination, addressing this significant area of research.

Finally, a crucial shortcoming revolves around the limited exploration of the quality of life and caregiver burden of AD patients. This highlights the necessity for a more holistic approach that comprehensively examines how sleep issues and treatments affect both patients and their caregivers. Bridging this gap is instrumental in advancing more comprehensive and effective care for AD patients.

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8 Appendices

Population/ Alzheimer's Disease	Intervention or Exposure/ Sleep Disturbances	Comparison/ Non-pharmacological	Outcome/ Alleviating interventions
Alzheimer's disease **OR** **Alzheimer*** **OR** **Alzheimer's**	**Sleep disorder*** **OR** **Sleep deprivation*** **OR** **Sleep*** **OR** **Sleep quality** **OR** **Sleep hygiene*** **OR** **Sleep duration**		**Alleviate** **OR** **Relieve** **OR** **Wellbeing** **OR** **Well-being**

Database/ Date/ Limits	Search phrase	Total number of hits/citations	Papers/records included based on title	Papers/records include based on abstract	Papers/records include based on full text
CINAHL	Alzheimer's disease OR Alzheimer* OR Alzheimer's AND Sleep disorder* OR Sleep deprivation* OR Sleep* OR Sleep quality OR Sleep wake disorder* OR Sleep duration AND Alleviate OR Relieve OR Wellbeing OR Well-being	2013-2023 34	Sundown Syndrome, Sleep Quality, and Walking Among Community-Dwelling People With Alzheimer Disease. Alzheimer disease: Sleep alleviates AD-related neuropathological processes. *Sleep and Alzheimer's disease: A pivotal role for the suprachiasmatic nucleus.* Light therapy and Alzheimer's disease and related dementia: past, present, and future. Effects of Meditation versus Music Listening on Perceived Stress, Mood, Sleep, and Quality of Life in Adults with Early Memory Loss: A Pilot Randomized Controlled Trial.	Light therapy and Alzheimer's disease and related dementia: past, present, and future.	Light therapy and Alzheimer's disease and related dementia: past, present, and future.
MEDLINE	"Alzheimer's disease" AND Sleep disorder* OR Sleep deprivation*	1986-2023 (103 results)	Effects of music interventions on sleep in		

	OR Sleep* OR Sleep quality OR Sleep wake disorder* OR Sleep duration AND Alleviate OR Relieve OR Wellbeing OR Well-being	2013-2023 (80 results)	people with dementia: A systematic review. Conquering insomnia helps people with Alzheimer's. Sleep hygiene programs, exercise and daytime exposure to light can alleviate sleep disturbances. Bright light therapy for elderly. Light therapy and Alzheimer's disease and related dementia: past, present, and future. Application of music therapy for managing agitated behavior in older people with dementia. Circadian rhythm disturbances in patients with Alzheimer's disease: a review. (https://www.hindawi.com/journals/ijad/2010/716453/)		
ProQuest Central	“Alzheimer’s disease” AND Sleep disorder* OR Sleep deprivation* OR Sleep* OR Sleep quality OR Sleep wake disorder* OR Sleep duration AND Alleviate OR Relieve OR Wellbeing OR Well-being	2013-2023 (7,005,132 results) —------- (then additional limitations, scholarly journals,			

		Dissertations & Theses, Books, Standards & Practice Guidelines) 1,048,338 results			
ProQuest Central	Non-pharmacological methods alleviate sleep disorders Alzheimer’s disease	2013-2023 (limitations, scholarly journals, Dissertations & Theses, Books, Standards & Practice Guidelines) 453 results			
Other	Treatment of sleep and nighttime disturbances in Alzheimer's disease: a behavior management approach Research advances in the study of sleep disorders, circadian rhythm disturbances and Alzheimer’s disease Clinical management of sleep disturbances in Alzheimer's disease: current and emerging strategies				

Table 2. Articles table

Author(s), year, country	Aim of the research	Study design and data analysis	Participants	Results
1.Ancoli-Israel et al. 2002 USA	To determine whether fragmented sleep-in nursing home patients would improve with increased exposure to bright light.	Randomized controlled trial. Data analysis -Actillum data. -Mean activity level per minute. - Periodic functions for activity. - Circadian rhythm analysis. -Parametric analysis.	77 participants	Not a single treatment group observed an increase with regard to daytime alertness or quality of sleep at night. Bright morning light increased the mean activity level (mesor) and delayed the acrophase, or peak, of the activity rhythm.The morning bright light group participants also shown improved activity rhythmicity over the course of the 10-day treatment. Results, however, revealed that strong light in the morning could postpone circadian rhythms and enhance the quality of circadian rhythms in residents of nursing homes.
2. McCurry et al. 2004 USA	To provide evidence of the potential utility of sleep hygiene recommendations and dementia education to reduce nighttime behavioral disturbances in persons with AD.	Case studies. Statistical analysis	3 participants	Subjective sleep evaluations, the frequency of nighttime awakenings, the quantity of daytime sleep, and actigraphic increases in sleep quantity and efficiency were all observed. One patient was still improving at the six-month follow up. The types of sleep issues that subjects experienced and the behavioral techniques used by family caregivers varied greatly, highlighting the complexity of AD's nighttime behavioral disturbances.
3. Dowling et al. 2005 USA	to test the effectiveness of morning bright light therapy in reducing rest–activity (circadian) disruption in institutionalized	Randomized, placebo-controlled, clinical trial. Data analysis -Actiware™ Sleep	46 participants.	In all experimental individuals as compared to control subjects in the intent-to-treat analyses, the morning bright light exposure regimen did not result in an overall improvement in sleep measurements or the rest-activity rhythm.

	patients with severe AD.	Version 3.2 program.		The patients who had a desynchronized rest-activity rhythm showed the greatest benefits; at the end of the intervention, sleep efficiency, nighttime sleep, and waking times all increased, and the gap between their least and most active periods increased.
4. McCurry et al. 2011 USA	To test the effects of walking, light exposure, and a combination intervention (walking, light, and sleep education) on the sleep of persons with Alzheimer's disease (AD).	Randomized, controlled trial with blinded assessors. Data analysis method -Stata version 11.1 (StataCorp, College Station, TX)	132 participants were randomized and 108 were analyzed.	A substantial improvement in total waking time (effect size 0.51–0.63) was seen in walking (P 5.05), light (P 5.04), and combination therapy (P 5.01) participants at posttest compared to controls, but no significant improvement was observed in the SDI. Among those receiving active therapy, there were also notable improvements in actigraphic sleep percentage with moderate effect sizes. At six months, no group differences were seen for any sleep outcome, and there were no significant differences across the active therapy groups either. There was a significant difference in total waking time (P 5.006) and sleep efficiency (P 5.005) between those who adhered better (4 d/wk) to walking and light exposure recommendations and those who did not.
5.Friedman et al.2012 USA	the effects of the light therapy and the sleep hygiene component on both the sleep and psychological status of the caregivers as well as the care recipients.	RCTs. Data analysis methods -Statistical analysis using post-hoc paired t-tests and Pearson correlation	54 caregiver-care recipient dyads	The results indicated that older people with memory problems or their carers did not benefit enough from a brief, 30-minute morning exposure to bright light to improve their sleep.
6.Figueiro et al. 2014 USA	Effectiveness of a tailored lighting intervention for individuals with ADRD living in nursing homes.	Quantitative. Data analysis method	14 participants	According to the study, individuals with ADRD residing in long-term care facilities can have better sleep and less agitation when a light distribution system is designed

	to investigate the efficacy and feasibility of a tailored lighting intervention designed to deliver high circadian stimulation at moderate light levels from a high-CCT white light source.	-Statistically analysis		to boost circadian stimulation during the day and decrease it at night, all without adding uncomfortable glare.
7. Nascimento et al. 2014 Brazil	To assess the contribution of a multimodal exercise program on the sleep disturbances (SD)and on the performance of instrumental activities daily living (IADL) in patients with clinical diagnosis of Alzheimer's disease(AD) and Parkinson's disease patients (PD).	Quantitative Data analysis method -Statistically analysis	35 demented patients with AD.	IADL and SD interactions were shown using two-way ANCOVA. Both intervention groups showed significant improvements for these characteristics, whereas the control groups showed either maintenance or worsening. These gains were demonstrated by the effect size study.
8.Sekiguchi et al. 2017 Japan	effectiveness of bright light therapy in improving sleep disturbances in people with dementia including Alzheimer's type dementia, vascular dementia, and dementia with Lewy bodies.	Case series	17 participants	Four subjects who were all AD patients saw an improvement in their sleep disruption after receiving BLT. The four AD patients either had mild to severe AD or had a shorter illness duration.
9. Kim et al 2017 South Korea	Based on each patient's unique circadian phase, the objective of this study was to compare the effects of timed blue-enriched white light treatment (timed BLT) and timed blue-attenuating	Quantitative Data analysis method -Statistical analysis (SPSS)	14 participants	Results could suggest that in individuals with mild to severe AD, timed BLT improves subjective sleep quality in a short- and long-term approach.In contrast to timed blue-attenuating LT, only this long-lasting impact was better. Due to the very limited sample size, type 2 errors may have been more likely to cause these conflicting findings

	light treatment (control) on sleep, cognition, mood, and behavior in patients with mild to moderate AD. (aim not mentioned)			about the immediate and long-term impacts on subjective sleep quality.
10. Figueiro et al. 2019 USA	Primary aim, to extend earlier studies and determine whether a tailored lighting intervention (TLI) delivering a high level of circadian stimulation would improve reported and objective measures of nighttime sleep. Secondary aim was to determine whether the TLI would improve caregiver-assessed participant scores in measures of depression, agitation, and quality of life.	A Randomized Clinical Trial Data analysis method -Statistical analysis	46 patients with ADRD	In comparison to the active baseline and control intervention, the active intervention markedly raised Pittsburgh Sleep Quality Index scores. Additionally, the intradaily variability of the active intervention was much higher than that of the control group. Regarding secondary outcomes, the Cornell Scale for Depression in Dementia scores showed notable improvements after the active intervention, and the Cohen-Mansfield Agitation Inventory scores showed considerably greater active differences than control. In controlled settings, people with dementia may experience improvements in behavior, sleep quality, and mood with a lighting intervention designed to fully synchronize the circadian rhythm.
11.Kouzuki et al. 2020 Japan	To evaluate aroma oil's impact on sleep quality, olfactory function, and cognitive function as a bath salt. To establish a new aromatherapy method that could improve cognitive function, olfactory function and sleep quality.	Randomized Controlled trial. Data analysis method -Correlation analysis.	35 participants (Alzheimer's disease: 10, mild cognitive impairment: 25).	According to the study's findings, using 0.1%, 0.5%, or 1% fragrance bath salt for 24 weeks did not enhance sleep quality, cognitive performance, or olfactory function. Furthermore, no variations in the effects of fragrance oil concentrations on sleep quality, olfactory function, or cognitive function were noted.

12. Figuero et al. 2020 USA	To determine whether long-term, 24-week TLIs that provide high levels of circadian stimulation throughout the day might enhance nighttime sleep in individuals with ADRD who live in controlled surroundings, in an effort to expand on our previous findings. To determine whether the TLI would improve caregiver-assessed participant scores in measures of depression, agitation, and quality of life in the same population.	Quantitative research. Data analysis method -Statistical analysis, SPSS, version 24.0, for Windows (SPSS Inc., Chicago, IL).	47 participants	The Pittsburgh Sleep Quality Index scores showed significant improvement with an estimated mean±SEM of 11.89±0.53 at baseline and 5.36±0.63 at the end of the intervention. Actigraph measures of sleep efficiency showed more improvements. Both the Cornell Scale for Depression in Dementia and the Cohen-Mansfield Agitation Inventory scores (mean±SEM of 35.33±2.23 at the conclusion of the intervention and 11.36±0.74 at baseline and 4.18±0.88 at the end of the intervention) were both substantially lowered by the intervention.
13.Fong et al. 2023 Hong Kong, China	To evaluate the effects of light therapy on the alleviation of sleep disturbances, agitation and depression in people with dementia.	A systematic review and meta-analysis of randomized controlled trials Data analysis method -RevMan 5.3	648 participants	While the long-term benefits of light therapy are yet unknown, it seems to be more successful in treating sleep disturbances than in lowering agitation or sadness.
14. He et al. 2023 China	To provide empirically-based recommendations for people living with Dementia (PlwD) with sleep disturbances and explore future research directions.	A systematic review and meta-analysis Data analysis method -Statistical analysis -RevMan	530 participants	This study showed that while light treatment and SSBM are somewhat beneficial in treating nighttime sleep, sleep disturbance, sleep efficiency, and depression in PlwD, PARO prolongs nighttime sleep in PlwD.