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간호학박사 학위논문

Effects of non-pharmacological interventions on sleep disturbances in night workers:
A systematic review and meta-analysis

야간 근무자의 수면 장애에 대한
비약물적 중재의 효과:
체계적 문헌고찰 및 메타분석

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간호학과 간호학 전공

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Effects of non-pharmacological interventions on sleep disturbances in night workers:

A systematic review and meta-analysis

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ABSTRACT

Sleep disturbances are notorious among night workers and remain as a popular target of research. Various adverse physiological and psychological problems in night workers are associated with sleep disturbances caused by chronic exposure to circadian misalignment. In 2007, the International Agency for Research on Cancer classified shift work including night work as a probable human carcinogen. Since then, researchers have conducted trials to investigate effects of various interventions in mitigating sleep problems. Although many have evaluated different sleep-mediating methods, there is a lack of study that summarizes currently existing interventions applicable to night workers and provides a pooled effect size of the interventions. Therefore, the primary objective of this systematic review and meta-analysis was to critically review and synthesize exiting literature on the impact of non-pharmacological interventions implemented among night workers in mitigating and decreasing sleep disturbances.

A systematic review was performed following the PRISMA reporting guideline. The leading study question and the selection criteria were developed using PICOTS-SD framework. MeSH terms, EMTREE terms, CINAHL headings and keywords representing each component of PICOTS-SD were selected to conduct a rigorous literature search using MEDLINE, EMBASE, CINAHL Plus with Full Text, PsycINFO databases, internationally renowned journals and grey literature.

Cochrane Risk of Bias tool was used to evaluate study quality and to identify potential risk of biases.

Of the 3,093 retrieved articles, 28 met our inclusion and exclusion criteria. Of these, 20 were included in the meta-analysis. We identified 6 non-pharmacological interventional methods: controlled light exposure, short-wavelength light protection, strategic naps, shift schedule modification, behavioral training and aromatherapy. Overall, non-pharmacological interventions had a significantly therapeutic effect on sleep disturbances in night workers compared to the control group who did not receive any treatment (Hedges' *g*= -1.43, 95% CI: -2.34, -0.53). The interventions showed significant effects on reducing sleepiness on-shift (Hedges' *g*= -2.83, 95% CI: -4.55, -1.10), increasing sleep length off-shift (Hedges' *g*= 0.76, 95% CI: 0.15, 1.37) and sleep quality off-shift (Hedges' *g*= -0.57, 95% CI: -0.81, -0.34) with medium to large effect sizes. Subgroup analysis based on the intervention types showed controlled light exposure to have a significant effect on reducing sleep disturbances (Hedges' *g*= -1.62, 95% CI: -2.81, -0.43). However, the effects of strategic naps and behavioral training were not significant. Non-pharmacological interventions showed a significant effect in night workers engaged in healthcare industries (Hedges' *g*= -1.28; 95% CI -2.48 to -0.07) and industrial or manufacturing industries (Hedges' *g*= -2.74; 95% CI -4.65 to -0.83).

The findings of the current study suggest non-pharmacological interventions to be favorable in mitigating sleep disturbances in night workers, with greatest impact apparent for sleepiness on-shift. The effect seems to be greatest when using the controlled light exposure intervention on night workers engaged in healthcare, industrial and manufacturing occupations. Our findings provide an objective and supporting evidence to incorporate various non-pharmacological interventions in improving sleep health among night workers. We also suggest further research to identify potential modifying factors and to establish optimal combination of strategies best suitable for real-world night work setting.

Keywords: Night Shift Work, Sleep Disturbance, Circadian Rhythm Sleep Disorders, Review, Systematic Review, Meta-Analysis

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CHAPTER I. INTRODUCTION

1. Background

Night work, including both fixed and rotating shift schedules, has become a norm rather than exception in the modern society with increased economic and social demands (Bekkers, Koppes, Rodenburg, van Steeg, & Proper, 2015). Various industries including sectors of healthcare, manufacturing, retail and transportation have become dependent on the around-the-clock operations with nearly 15 to 20% of workforce employed as night workers in industrialized countries (James, Honn, Gaddameedhi, & Van Dongen, 2017; F. Wang et al., 2014). The night work has allowed economic productivity and consumer convenience by establishing 24-hour operations, making such work schedule a vital component of the current society. However, work at night, irrespective of fixed or rotating types, commonly leads to development of sleep disturbances (Ko, 2013; F. Wang et al., 2014).

Night work-related sleep disturbances including increased sleepiness, altered sleep length and reduced sleep quality are found to have negative effects on both individual and organizational aspects. Insufficient sleep is highly likely to cause numerous psychological and physical health issues and to decrease quality of life (W. Kim, Kim, Lee, Choi, & Park, 2016; Nena et al., 2018). Night workers are prone to a wide range of sleep-related problems due to prolonged and chronic exposure to misaligned circadian rhythms, which are involved in controlling melatonin expression, sleep/wake patterns, food digestion, hormone secretion and many other intricate physiological processes (Buijs, Escobar, & Swaab, 2013; Lavoie et al., 2010). Thus, working at night hours increases the risk of disrupting internal physiology which may result in multiple negative health outcomes (Caruso, 2014).

Night workers may display a wide range of sleep-related symptoms. They may experience short-term symptoms such as sleepiness, tiredness and fatigue (Cingi, Emre, & Muluk, 2018; James et al., 2017). However, these symptoms may further develop into more serious and chronic psychological and physiological problems. Several epidemiological studies and cohort studies have found significant associations between night work and social isolation (Skoufi et al., 2017), emotional disturbances such as mood swings, anxiety, depression and decreased quality of life (Kalmbach, Pillai, Cheng, Arnedt, & Drake, 2015). Moreover, the incidence rates of chronic illnesses including cardiovascular disease (D. Wang, Ruan, Chen, Peng, & Li, 2018), fatty liver disease (Lin & Chen, 2015), diabetes mellitus (Zoto, Cenko, Doci, & Rizza, 2019), hypertension (Ohlander, Keskin, Stork, & Radon, 2015) and metabolic syndrome (F. Wang et al., 2014) are reported to be higher among night workers. The night work exposure, especially with long-term, was also found to be associated with increased potential risk of a plethora of cancers including breast (P. Wang et al., 2015), ovarian (L. Leung et al., 2019), stomach (Gyarmati et al., 2016), colorectal (X. Wang et al., 2015) and prostate cancers (Gan et al., 2018). The frequent sleep disturbances among night workers may also affect organizations by increasing the risks of job dissatisfaction, turnover rates and occupational injuries (Wong, McLeod, & Demers, 2011). Thus, epidemiological studies and review studies examining the association between night work and health issues have suggested implementation of various interventional approaches in workplaces in preventing and reducing sleep disturbances (Costa, 2003; Ganesan et al., 2019; James et al., 2017; Wickwire, Geiger-Brown, Scharf, & Drake, 2017).

Studies have evaluated several pharmacological and non-pharmacological interventional methods in laboratory and field settings to reduce and improve sleep disturbances in night workers. Several trials and review studies have shown significant effects of pharmacological methods such as exogenous melatonin administration in facilitating sleep quality and length (Sadeghniiat-Haghighi, Aminian, Pouryaghoub, & Yazdi, 2008) or stimulating agent administration such as caffeine (Centofanti et al., 2018), Modafinil and Armodafinil (Darwish, Bond, & Ezzet, 2012) in reducing drowsiness and sleepiness. Although administering pharmacological aids or other substances may be a more convenient method of choice, it has potential for drug-related tolerance or dependency and may be contraindicated to those with comorbidities. Non-pharmacological interventions refer to a variety of approaches including exposure to stimulant environment conditions (e.g. light therapy), cognitive or behavioral techniques (e.g. cognitive behavioral therapy, behavioral training, sleep hygiene education), lifestyle modifications (e.g. strategic naps), and shift schedule changes. Non-pharmacological interventions are less likely to cause side effects, and may be safer and more appropriate for workplace implementation compared to pharmacological agents.

Although non-pharmacological interventions may be safer, limited number of review studies have been conducted to summarize their therapeutic effects. The majority of reviews have focused on a singular methodology such as light therapy (van Maanen, Meijer, van der Heijden, & Oort, 2016), strategic naps (Martin-Gill et al., 2018; Ruggiero & Redeker, 2014) or shift schedule changes (Bambra, Whitehead, Sowden, Akers, & Petticrew, 2008). These reviews also included trials conducted on non-night workers in simulated laboratory settings, making study results questionable for its external validity. They also assessed outcomes irrelevant to sleep disturbances and health consequences. As of our knowledge, only two studies reviewing the effects of non-pharmacological interventions on night workers have been published. However, one study failed to perform meta-analytic synthesis and combined pharmacological and non-pharmacological methods (Neil-Sztramko, Pahwa, Demers, & Gotay, 2014). Another review included meta-analysis to provide pooled effect size of interventions, but included simulated laboratory-based studies (Slanger et al., 2016). Therefore, this study aimed to synthesize field-based study results reporting non-pharmacological interventions to reduce sleep disturbances in night workers.

2. Purpose

The purpose of this study was to provide a comprehensive understanding of non-pharmacological interventions in reducing and resolving sleep disturbances among night workers and to provide a global index on the effect magnitude of identified interventions using approaches of systematic review and meta-analysis.

The specific aims were (1) to systematically review the literature and identify currently available non-pharmacological strategies in improving sleep disturbances among night workers, (2) to synthesize pooled effect of identified strategies in mitigating and improving sleep among night workers, and (3) to assess quality of evidence to provide future directions and implications for research and practice guidelines.

3. Terminology

1) Shift work/night work

The term “shift work” lacks a consistent definition, and implies broad and narrow spectrums of meanings (Wickwire et al., 2017). In a broad perspective, the International Labour Office’s (ILO) definition implies “a method of organization of working time in which workers succeed one another at the workplace so that the establishment can operate longer than the hours of work of individual workers (International Labour Office, 1990).” According to this definition, a nearly infinite variety of forms of shift work schedules can exist to have workers alternate in succession to accommodate various periods of demands and to increase the total work time (International Labour Office, 2004). In the scientific literature, the term ‘shift work’ generally refers to a narrower perspective and implies an arrange of working hours other than the standard daylight hours that includes at least a portion of the shift occurring during the night hours (Caruso, 2014; Costa, 2003; Knutsson, 2004; Noh et al., 2010). Usually, any organizational working time covering more than the usual 8-hours during the day time is considered as shift work, and the hours extend up to 24-hour period. Although the time intervals of night work hours may differ depending on the industries and countries, most literature follow the ILO’s definition: “all work which is performed during a period of not less than seven consecutive hours, including the interval from midnight to 5 a.m.” (International Labour Office, 2004). There is no standard definition, but some studies have classified night work as ‘working three night shifts per month’ (Stevens et al., 2011). In this study, the ILO’s definition was used as the operating definition of “night work.” Workforces that require regular work on the same night shift (i.e. fixed night shifts) and those involving rotating shift schedules to cover days and nights were both regarded as “night work.”

2) Non-pharmacological intervention

A number of strategies have been proposed to help individuals adapt to working at night hours. In this study, any interventional methods other than administration of pharmacological agents (e.g. exogenous melatonin, caffeine, Modafinil, Armodafinil) or any other stimulants are considered non-pharmacological interventions (Centofanti et al., 2018; Neil-Sztramko et al., 2014; Sun et al., 2018). Previous review studies that described some of the available interventional methods for night workers and/or shift workers were used as a guidance in retrieving scientific literature. The most commonly identified interventions for night workers’ sleep health include exposing to bright light, napping, rearranging shift schedules and adjusting behaviors while awake (Centofanti et al., 2018; Martin-Gill et al., 2018; Martinez & Lenz Mdo, 2010; Neil-Sztramko et al., 2014; Sun et al., 2018).

3) Sleep disturbances

The conceptual definition of sleep is a natural physical and mental resting state where the subject displays a readily reversible suspension and insensitivity of sensorimotor interaction with the external stimuli (Carskadon & Dement, 1994). It is well-established that good sleep is an essential component to good health.

However, sleep disturbances that threatens good sleep health is not explicitly defined (Buysse, 2014). It is rather constructed with the following five measurable sleep characteristics (Buysse, 2014):

- Sleepiness: the ability to maintain attentiveness during the wakeful hours
- Sleep length or duration: the total amount of sleep hours obtained per 24 hours
- Sleep quality or satisfaction: the subjective assessment and reports of ‘good’ or ‘poor’ sleep
- Sleep efficiency or continuity: the ease of falling asleep
- Sleep timing: the placement of sleep within the 24-hour period

Among these measures, previous review studies have indicated that the major sleep complaints of night workers are being sleepy at work, having short sleep length and decreased sleep quality after work (Liira et al., 2014; Slanger et al., 2016). Population-based studies have also reported night workers are significantly more likely to report sleepiness on waking, insufficient sleep and to indicate poor sleep quality compared to the general population (Akerstedt, Ingre, Broman, & Kecklund, 2008; L. C. Yong, Li, & Calvert, 2017). In this study, sleep disturbances refer to three main aspects of night workers’ sleep complaints: sleepiness on-shift, reduced sleep length off-shift and decreased sleep quality off-shift. Trials that have measured any of these three outcome aspects were eligible for inclusion.

CHAPTER II. LITERATURE REVIEW

1. Night work and sleep physiology

Sleep and wakefulness are thought to be endogenously regulated by "two-phase" model (Borbely, 1982; Borbely, Daan, Wirz-Justice, & Deboer, 2016). This model suggests that the physiologic process of sleep is controlled, in part, by a homeostatic mechanism where the pressure for sleep increases in proportion to the previous awake time, and, in part, by the light-sensitive circadian rhythm driven by the internal biological clock located near suprachiasmatic nucleus of the anterior hypothalamus (Wickwire et al., 2017). The 24-hour cycle of circadian rhythm synchronization is adjusted by the amount of light and darkness of the surrounding environment that are transmitted through the retina and sent to the suprachiasmatic nucleus via the retinohypothalamic and geniculo-hypothalamic tracts (Cingi et al., 2018). The amount of light and darkness sent through the tracts is a key determinant factor of the endogenic production of melatonin—a hormone that is closely associated with control of sleep/wake behavior (Cingi et al., 2018). As the amount of light transmission increases with the sunrise, the level of melatonin secretion in pineal gland starts to be suppressed, which, then, signals the internal clock to activate the central nervous system (CNS) arousal and facilitate wakefulness (Shanahan, Kronauer, Duffy, Williams, & Czeisler, 1999). On contrary, decreased light transmission in the evening results in the rise in melatonin secretion, which suppresses the CNS and promotes sleep onset (Wickwire et al., 2017).

Night work schedules create a conflict with the aforementioned endogenous rhythm of sleep/wake cycles, and night workers' behaviors override the natural physiological mechanisms. In night workers, a misalignment between environmental cues and the two-phase model mechanisms is commonly induced, resulting in disruptions in both sleep and wakefulness. Their external daytime, the hours of activities and wakefulness, occurs during peak hours of melatonin circulation, and, thereby, causes desynchronization in circadian rhythm (Wickwire et al., 2017). Night workers are expected to be awake and active when the circadian arousal is at the weakest, which often leads to excessive on-shift sleepiness. On the other hand, they are most likely to go to bed during the daylight hours when the circadian alerting signal is strongest. This often leads to early awakenings, fragmented sleep, reduced sleep length and decreased sleep quality.

2. Night work and health

Nevertheless, a disruption in the functional rhythms of being active during the day and sleeping at night increases odds of developing sleep disturbances (Costa, 2015). Despite the high risks for sleep health problems, the number of workforce segment involved in non-traditional work schedules is rapidly rising worldwide, especially for those working at night hours (Gan et al., 2015). National data from various industrial continents including Europe, North America and Asia have reported that the portion of night workers are on a steady rise (Eurofound, 2017; Son, J., Kim, Kang, & Jung, 2015; Statistics, 2017). According to the Eurofound's most recent European Working Conditions Survey (EWCS) involving 28 European nations, night work population has rose from 17% in 2005 to 21% in 2010 (Eurofound, 2017). The U.S. Census Bureau's National Health Interview Survey

(NHIS) data has shown 15% of the U.S. workforce in 2016 to be working at night (Statistics, 2017). Similarly, the Korea National Health and nutrition Examination Survey (KNHANES) data has reported 10.2% to 14.5% of all wage workers in 2011 to be engaged in night work (Son et al., 2015).

Shift work may be unavoidable for the current society requiring 24/7 services. However, shift workers report more sleep problems than the general public (Flo et al., 2013). As expected, a large number of night workers experiences sleep disturbances characterized by excessive sleepiness during the desired waking period (i.e. during the night hours while at work) and decreased sleep length and quality during the allowed sleep period (i.e. during the day light hours after work) (Ganesan et al., 2019). A robust evidence illustrates the negative health consequences of night work. Not only do night workers experience excessive sleepiness, shorter sleep length and poorer sleep quality, these workers are at a higher risk for medical complications as opposed to the traditional, daytime workers. Night work has been linked to both psychological and physical problems including depression (A. Lee et al., 2017), anxiety (Kalmbach et al., 2015), abuse of alcohol and other detrimental substances (Morikawa, Sakurai, & Nakamura, 2013), cardiovascular diseases (D. Wang et al., 2018), cerebrovascular events including stroke (Li, Huang, Tan, Yang, & Tang, 2016), gastrointestinal complaints (Vener, Szabo, & Moore, 1989), metabolic syndrome (Lim, Hoe, Darus, & Bhoo-Pathy, 2018), obesity (Bekkers et al., 2015), sexual dysfunction (Valenzuela-Peters, Contreras-Garcia, & Manriquez-Vidal, 2017), and multiple forms of cancer (M. Yong, Nasterlack, Messerer, Oberlinner, & Lang, 2014). Although these health problems may occur due to a mixture of innumerable risk factors, large body of individual studies and review studies have indicated sleep disturbances to be one of the strongest influencing factor in night workers.

3. Night work adaptation

Individual differences have been identified to have effects on variability on workers' ability to tolerate and adapt to the night work characteristics (Saksvik, Bjorvatn, Hetland, Sandal, & Pallesen, 2011). Few night workers may well-adapt and obtain adequate sleep off-shift and stay alert on-shift, whereas the majority of the night workforce is most likely to develop sleep disturbances. The mechanisms on the individual variations to adapt to night work is complex and still not fully understood (Akerstedt & Wright, 2009; Wickwire et al., 2017). Currently, only limited number of hypotheses are available in possibly explaining the physiologic mechanisms of workers demonstrating tolerance to night work and remarkable degree of circadian adaptation. These few studies have suggested genetic traits, work-related traits and individual traits as potential contributing factors.

Genetic traits of morningness or eveningness refer to the periods of time when the subjects are most alert and functional (Taillard, Philip, & Bioulac, 1999). These traits are also described as 'morning larks,' individuals who have highest energy in the early morning hours and 'night owls,' individuals who have highest energy in the late afternoon (Hidalgo, de Souza, Zanette, & Nunes, 2003; McEnany & Lee, 2000). This individual tendency and preference is thought to be linked to the length of polymorphism of the PER3 gene—the "clock gene," which regulates sleep/wake cycles (Archer et al., 2003; Leocadio-Miguel et al., 2018). Morning-type individuals have been shown to exhibit reduced tolerance and maladaptation to night work, and their coding region of the PER3 gene has been linked to the resistance to sleepiness and decreased performance due to sleep decrements (Viola, Archer, & James, 2007; Wickwire et al., 2017). Also, genetic polymorphisms of melatonin profile and dim-light onset of melatonin have been suggested to explain degree of circadian adaptation in night workers (Gumenyuk, Belcher, Drake, & Roth, 2015; Gumenyuk, Howard, Roth, Korzyukov, & Drake, 2014). Work-related and individual traits have also been proposed to have an influence on one's night work adaptability. Factors associated with the work schedules include the length and time of night work itself, constancy of night work and work intensities (Wickwire et al., 2017). Also, individual night work history, medication use, activity levels during the awake period, time spent in bed and social and family responsibilities have been identified as possible influencing factors (Drake, Roehrs, Richardson, Walsh, & Roth, 2004; Wickwire et al., 2017). Although these potential factors have been identified, only limited supporting evidence is available. There is a lack of longitudinal studies investigating the predictive values of different traits for night work tolerance (Harma, 1993; Saksvik-Lehouillier et al., 2013; Saksvik et al., 2011). Thus, studies have suggested developing and implementing interventions and investigating the predictive values of interventional methods to aid and promote night workers' health.

CHAPTER III. CONCEPTUAL FRAMEWORK

In order to speculate the effects of a wide range of anticipated non-pharmacological interventions on sleep disturbances in night workers, the following conceptual framework was developed prior to the systematic search of literature.

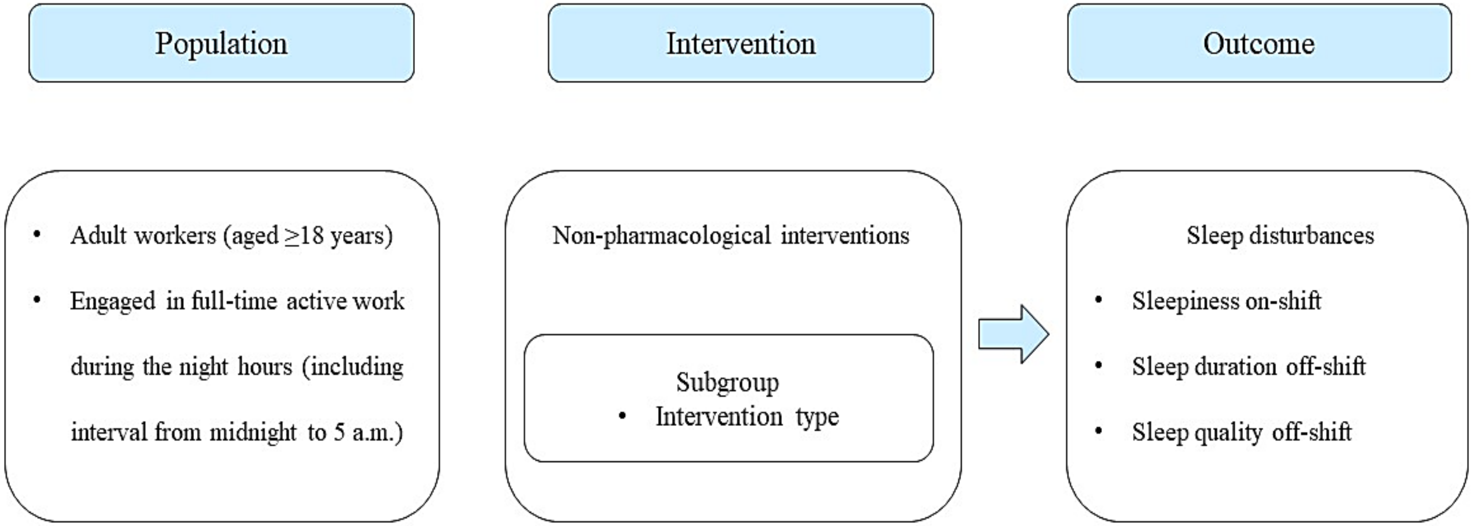


Figure 1 Conceptual framework

CHAPTER IV. METHODOLOGY

1. Study design

This systematic review and meta-analysis aimed to collectively assess non-pharmacological interventional methods in night workers' sleep health promotion and to determine the effectiveness of suggested interventions. This study was planned, conducted and reported in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA) reporting guideline (Moher, Liberati, Tetzlaff, Altman, & Group, 2009) (Appendix 1).

2. Study question and selection criteria

The leading study question and the selection criteria of this systematic review and meta-analysis were developed using PICOTS-SD (Population; Intervention; Comparison; Outcome; Time (follow-up); Setting; Study design) framework as recommended by the Cochrane Collaboration and the National Evidence-based Healthcare Collaborating Agency (NECA) (J. P. Higgins, 2011; S. Y. Kim et al., 2011). Based on the PICOTS-SD, this systematic review and meta-analysis aimed to answer the following two leading study questions: (1) "what are the non-pharmacological strategies currently available in preventing and alleviating sleep disturbances caused by night work schedules?" (2) "are the identified non-pharmacological interventions effective in mitigating and/or improving sleep disturbances in night workers?" Studies that fulfilled all aspects of PICOTS-SD upon careful full-text reviews were selected as the final inclusion (Table 1). The details of inclusion and exclusion criteria for primary PICOTS-SD components and publication types to answer the leading study questions are as of the following:

1) Types of population

Trials conducted on adult workers aged ≥18 years engaged in night work positions were included in this systematic review. Any industry, country, gender or sleep health status at the time of enrollment were accepted for potential eligibility. Laboratory trials that reinforced simulated wake/sleep circadian misalignment on healthy adults, university students or any other subjects with no shift work experience to mimic the sleep disturbances caused by night work were excluded from this review.

2) Types of interventions

Non-pharmacological interventions that were clearly defined were included. Trials that compared combination therapy (combined pharmacological and non-pharmacological therapy) with other pharmacological intervention or no intervention were excluded due to difficulty of identifying single effect.

3) Types of comparator

Trials that compared any non-pharmacological interventions with any other alternative interventions or no intervention were included.

4) Types of outcome measurement

Studies that clearly stated the method of outcome measurement and defined sleep disturbances were included. Studies that defined the presence of sleep disturbances caused by night work within the following three categories were included: sleepiness on-shift, altered sleep length off-shift, and reduced sleep quality off-shift.

5) Time—intervention duration

No restriction on intervention duration was considered.

6) Types of setting

No restriction on intervention delivery setting was considered.

7) Types of study design

Randomized controlled trials (RCT) including parallel and cross-over designs were included in this review. The Design Algorithm for Medical Literature on Intervention (DAMI), a reliable and valid tool for study design evaluation in systematic reviews, was used to in minimize errors in study selection and data extraction processes study design, instead of relying on what the study author has proposed (Seo et al., 2016) (Appendix 2). We included studies that provided with full-texts. Studies retrieved from grey literature search process, which were unpublished or published as abstracts only, were excluded if they did not provide sufficient overview of data for meta-analytic synthesis. Non-experimental studies including observational studies, corresponding letters and reviews were also excluded. However, the reference lists of these non-experimental studies were assessed for any relevant RCT studies. As mentioned earlier, we excluded laboratory trials in which recruited population, who have never worked night positions, were exposed to intervention in a simulated setting.

8) Types of publication

Original studies with accessible full-texts were included. Rigorous searching process was conducted in order to retrieve all full-texts of potential studies. A librarian was consulted and the corresponding authors were contacted via e-mail in the case of irretrievable article. Studies with no accessibility to the original full-texts, ongoing studies with inconclusive findings, studies with insufficient data for meta-analysis, abstracts, posters, summaries, reviews, letters, corresponding statements were excluded.

Table 1 PICOTS-SD of the study

Categories	Criteria
Population	Adult workers engaged in night work or night shift work schedules, irrespective of industry, country, gender, age, or sleep health status at the time of study enrollment
Intervention	Any clearly stated non-pharmacological intervention
Comparison	No use of non-pharmacological intervention or an alternative intervention
Outcome	Presence of sleep disturbances as defined by the followings: 1) Sleepiness on-shift: ▪ Subjective/self-rated sleepiness measured by validated questionnaires ▪ Objective sleepiness measured by physiological measurements and tests 2) Sleep length off-shift: ▪ Subjective/self-reported length of sleep by validated questionnaires or sleep diaries • Objective/recorded length of sleep by wrist-worn actigraphy or polysomnography 3) Sleep quality off-shift: ▪ Subjective/self-rated sleep quality by validated questionnaires ▪ Objective/recorded global sleep quality score by wrist-worn actigraphy or polysomnography
Intervention duration	No restriction; any clearly stated intervention duration accepted
Setting	No restriction; any clearly defined 24-hour operation work setting, home setting, etc., but excluding artificially simulated laboratory setting
Study design	Randomized controlled trials ▪ Parallel design ▪ Cross-over design
Publication	Accessible original full-text studies No restriction on publication year

3. Search sources and strategy

A comprehensive and reproducible literature search was performed after the search protocol and search vocabulary selection checklist were standardized based on the guidelines of the Cochrane Handbook (J. P. Higgins, 2011). The comprehensive review of the literature was conducted by systematically searching for any relevant studies through several databases and journal inceptions. A rigorous effort was made to retrieve articles published up to the final date of the search process, April 30th, 2019. The electronic databases for the literature search process were selected according to the National Library of Medicine (NLM)'s COre, standard, Ideal (COSI) model (S. Y. Kim et al., 2011). The COre databases are central search engines that are highly likely to produce the best results, whereas the Standard and Ideal databases provide probable and possible results, respectively. In order to minimize any selection bias, we included multiple electronic databases and journal inceptions for each COSI category. MEDLINE and EMBASE were included to fulfil the COre database category; CINAHL Plus with Full Text, PsycINFO and several internationally renowned journals such as Annals of Work Exposures and Health, Behavioral Sleep Medicine, Chronobiology International, Journal of Occupational Health, Journal of Sleep Research, Occupational Medicine, Sleep, Sleep Medicine, Sleep Medicine Reviews and Sleep Science for hand search of relevant articles were included for the Standard databases; and ClinicalTrials.gov, Grey Literature Report, Open Grey and ProQuest Dissertations & Theses databases were searched for the Ideal database selection (Table 2).

After preliminary search, an expert medical librarian was consulted in designing advanced search strategies specific to each database. With expert advice, search concepts, keywords and key references were identified to revise the preliminary search, and the final search process was conducted on May 12th, 2019. The intervention criteria of interest cover a broad spectrum and may not be well described in the title or abstract or not indexed very well with controlled vocabulary terms. Therefore, we searched for the population and outcome using a broad range and wide variety of preselected search terms. Appropriate subject headings specific to each database (e.g. Medical Subject Headings (MeSH), EMTREE terms, CINAHL headings) and free-text words were logically combined using the Boolean operators "OR," "AND," and "NOT." For the free-text words, synonyms, spelling variants, plurals, related terms, acronyms, truncations, wildcards and proximity operators were incorporated accordingly to increase search sensitivity. Because the key population search terms 'night' or 'shift' have led to an extremely high number of citations when searched alone, each term was combined with other terms that described aspects of 'the condition of working during the night hours' (e.g. 'night shift*,' 'nighttime shift*,' 'shift work*,' 'shift schedu*,' 'graveyard shift*,' 'midnight work*'). Similarly, the key outcome search term 'sleep' was combine with other terms to describe 'the condition of disrupted, altered, reduced or distorted sleep' (e.g. 'sleep disturb*,' 'sleep disord*,' 'sleep onset*,' 'circadian disrupt*,' 'circadian rhythm*'). Per Cochrane Handbook's recommendation, we minimized use of limit filters for interfaces during the search process to retrieve maximum data possible. Restrictions on publication date, format or language were avoided (Appendix 4).

Table 2 Database selection

COSI categories	Databases
COre	1) MEDLINE (OVID; https://www.ncbi.nlm.nih.gov/pubmed/) 2) EMBASE (https://embase.com/)
Standard	1) CINAHL Plus with Full Text (EBSCO; https://web.ebscohost.com/) 2) PsycINFO (EBSCO; https://search.ebscohost.com/) 3) Annals of Work Exposures and Health 4) Behavioral Sleep Medicine 5) Chronobiology International 6) Journal of Occupational Health 7) Journal of Sleep Research 8) Occupational Medicine 9) Sleep 10) Sleep Health 11) Sleep Medicine 12) Sleep Medicine Reviews 13) Sleep Science
Ideal	1) ClinicalTrials.gov (https://clinicaltrials.gov/) 2) Grey Literature Report (https://www.greylit.org) 3) Open Grey (https://www.opengrey.eu/) 4) ProQuest Dissertations & Theses (https://www.proquest.co.uk)

4. Study selection

The literature search and study selection process were conducted based on the PRISMA reporting guidelines (Moher et al., 2009). All retrieved data were assessed for predefined selection criteria, and their citations were organized using an electronic bibliography management software (EndNote X8, Clarivate Analytics). For the search and selection process, a second reviewer was available for consultation and discussion to make clarification and to reach a consensus decision of any articles with unclear suitability. All potentially eligible studies retrieved from each database were combined and screened for duplicates. After duplicate removal, the titles and abstracts were reviewed for the PICOTS-SD elements. In case of ambiguous or unclear information to make decision based on the title and abstract review, studies were included for the full-text review process. Full-text review was conducted on studies that were identified to fulfil PICOTS-SD or had unclear information based on title and abstract review to make definitive final decisions. In the full-text screening process, studies that had clear reasons were excluded. The reference lists of studies included in the full-text review were screened for any relevant findings that were missed. The study selection process final number of included and excluded studies with reasons were illustrated as a PRISMA flow diagram (Figure 2).

5. Data extraction

A structured template was predefined and designed prior to the literature search process to ensure the consistency of data extraction. The data extraction template for this study was developed by adopting and customizing the “Data collection form for intervention reviews: RCTs and non-RCTs” of the Cochrane Collaboration (J. P. Higgins, 2011) (Appendix 5). Some new sections were added and irrelevant sections were removed from the original form to answer our study questions. All identified studies were given study identification number, and general information were extracted (study title, surname of first author, year of study publication, publication type, country of study, etc.). Study eligibility was assessed by extracting the PICOTS-SD components, and, if the study was eligible for the final inclusion, study details were extracted. (Appendix 6).

6. Assessment of risk of bias

In this study, the Cochrane Risk of Bias tool (RoB 2.0), the most widely used quality assessment tool in systematic reviews of randomized trials, was used in assessing included studies' risk of bias (J. P. Higgins, 2011). We have used the latest updated version of the RoB tool, which was first released through the Cochrane Handbook for Systematic Reviews of Interventions in 2008 (J. Higgins et al., 2016). Each trial was assessed for RoB on the following six domains: selection bias, performance bias, detection bias, attrition bias, reporting bias and other sources of bias. The selection bias included assessment of random sequence generation and allocation concealment; the performance bias included assessment of blinding of participants and personnel; the detection bias included assessment of blinding of outcome assessment; the attrition bias included incomplete outcome data and reporting bias included selective outcome reporting (J. Higgins, Churchill, Chandler, & Cumpston, 2017; J. Higgins et al., 2016; J. P. Higgins, 2011; Knoll et al., 2018) (Table 3) When RoB was unclear in any domain, an attempt was made to obtain the study protocol through electronic database search or to contact the corresponding author of the original study. Review Manager software (RevMan 5.3, Copenhagen, Denmark) supplied by the Cochrane Collaboration was used to create a RoB summary graph for visual illustration for each domain in each study (Figure 3 and Figure 4).

Table 3 A common classification scheme for bias

Type of bias	Description	Relevant domains in the Cochrane Risk of Bias tool
Selection bias	Systematic differences between baseline characteristics of the groups that are compared	Sequence generation Allocation concealment
Performance bias	Systematic differences between groups in the care that is provided, or in exposure to factors other than the interventions of interest	Blinding of participants and personnel Other potential threats to validity
Detection bias	Systematic differences between groups in how outcomes are determined	Blinding of outcome assessment Other potential threats to validity
Attrition bias	Systematic differences between groups in withdrawals from a study	Incomplete outcome data
Reporting bias	Systematic differences between reported and unreported findings	Selective outcome reporting
Other sources of bias	Systematic differences relevant only in certain circumstance	Contamination between groups

Higgins JPT, Altman DG, Sterne JAC (editors). Chapter 8: Assessing risk of bias in included studies. In: Higgins JPT, Churchill R, Chandler J, Cumpston MS (editors), Cochrane Handbook for Systematic Reviews of Interventions version 5.2.0 (updated June 2017), Cochrane, 2017. Available from www.training.cochrane.org/handbook

7. Statistical analysis

The main purpose of meta-analysis is to quantitatively transform statistical values presented in various formats into a uniform effect size (J. P. Higgins, 2011). In order to perform a comprehensive analysis, the size of the treatment effects presented in individual studies is translated into a common measurement unit since the statistical methods may vary among the studies included in the review. Meta-analysis, therefore, transforms the results of each individual study into the same data, called an effect size. This effect size is typically calculated as standardized mean difference (SMD), correlation coefficient (*r*) and ratios (risk ratio, odds ratio or risk difference) depending on the reporting of the dependent variables. In this study, we used the effect size calculation method using the SMD due to quantitatively analyzing continuous data results. Several formulas are available for effect size calculation including Glass' Δ, Cohen's *d* and Hedges' *g*. Glass' Δ formula is fairly easy to calculate, but it requires satisfaction of the assumption that the variance between experimental and control groups are homogenous (Glass, 1976). Both Cohen's *d* and Hedges' *g* are widely accepted effect size indexes. However, for calculation of studies with very small sample sizes, Cohen's *d* is not appropriate due to its likelihood of overestimate the effect size. Therefore, in this study, Hedges' *g* index was chosen for the effect size calculation. The summary effects and the 95% confidence interval (CI) were calculated by applying a random-effects model in recognition of the diversity of research methods, samples, intervention methods and outcome measures in each study (Pio, Chaves, Davies, Taylor, & Grace, 2019). This model assumes that the studies included in the meta-analysis yield a random sample of effect sizes and allows for the true effect size to vary between studies (van Maanen et al., 2016). The weight of each effect size was calculated using inverse variance method (J. P. Higgins, 2011) (Table 4). We followed Cohen's standardized mean difference effect size analysis method and 95% CI to analyze the calculated effect size (Cohen, 1977; Hak, Van Rhee, & Suurmond, 2016; J. P. Higgins, 2011). The Cohen proposed the effect size of the SMD to be interpreted as small, moderate and large effect sizes (Table 5). The quantitative calculations and syntheses to produce the effect size of non-pharmacological interventions applied to night workers with sleep disturbances were performed using the Cochrane Collaboration's RevMan program.

Once the effect size and the 95% CI were calculated, the forest plot was drawn to visually identify the presence of heterogeneity, the between-study variability. The statistical heterogeneity amongst included studies was examined qualitatively by calculating and visualizing the forest plots. Also, the Cochrane Q statistics and the Higgins I^2 statistic were utilized to calculate and describe the percentage of total variation across trials (J. P. Higgins, Thompson, Deeks, & Altman, 2003). The Q statistics based on the chi-squared distribution where the null hypothesis assumes that 'all effect sizes are homogeneous,' and the alternative hypothesis assumes 'all effect sizes are heterogeneous' (J. P. Higgins, 2011).

The I^2 test is a relative measure for the proportion of observed variance that reflects real differences in effect size (Hak et al., 2016) Negative values of I^2 are set to zero, and it ranges from 0%, no observed heterogeneity, to 100%, maximal heterogeneity. The interpretations of the magnitude of calculated I^2 were based on the tentative classification proposal (J. P. Higgins & Thompson, 2002). The percentages of around 25% (I^2 = 25), 50% (I^2 = 50) and 75% (I^2 = 75) were interpreted as low, moderate and high heterogeneity, respectively (J. P. Higgins & Thompson, 2002; Huedo-Medina, Sanchez-Meca, Marin-Martinez, & Botella, 2006). As suggested by Higgins and previous meta-analysis studies, an I^2 greater than 50% was considered substantial heterogeneity (J. P. Higgins & Thompson, 2002; Huedo-Medina et al., 2006; Knoll et al., 2018) (Table 6).

The meta-analysis results were stratified by sleep disturbance types (sleepiness on-shift, sleep length off-shift, sleep quality off-shift), non-pharmacological intervention type (controlled light exposure, strategic naps, behavioral training) and occupation types (healthcare, industrial or manufacturing, others) to perform subgroup analysis in exploring potential moderators within each of these subgroups. Meta-regression, which tests study-level moderator effects of continuous sources such as mean age on heterogeneity, requires at least 10 study results for each moderator (J. P. Higgins, 2011; J. P. Higgins & Thompson, 2002). Thus, we were unable to perform meta-regression due to insufficient number of studies and data.

The DerSimonian and Laird method was used to indicate the between-studies variance (J. P. Higgins, 2011). Tau-squared, τ^2, is the variance of the true effect sizes and is used to assign weights under the random effects model, where the weight assigned to each study was according to the following equation (J. P. Higgins, 2011).

$$W_i = \frac{1}{V *_{Y_i}} = \frac{1}{Vy_i + \tau^2}$$

The total variance for an included study ($V *_{Y_i}$) is the sum of the within-study variance (Vy_i) and the between-studies variance (τ^2).

In addition to the subgroup analyses, we performed sensitive analyses to possibly explain between-study variabilities. As Cochrane Handbook has suggested, we assumed that the heterogeneity arose due to the presence of one or two outlying studies with incoherent results (J. P. Higgins, 2011). The primary meta-analyses were repeated after removing one or two studies that showed extreme heterogeneity.

Table 4 The Hedges' effect size and inverse variance weight calculation formula

Calculation formula	
$g = \dfrac{X_1 - X_2}{S_P}$	g = Hedges's g X_1 = $\mathrm{Mean}_{\mathrm{experimental}}$ X_2 = $\mathrm{Mean}_{\mathrm{control}}$ S_p = Pooled standard deviation
$S_p = \sqrt{\dfrac{(n_1 - \mathbf{1})S_1^{\mathbf{2}} + \left((n_2 - \mathbf{1})S_2^{\mathbf{2}}\right)}{(n_1 + n_2 - \mathbf{1})}}$	S_p = Pooled standard deviation n_1 = Total number of subjects in experimental group n_2 = Total number of subjects in control group S_1 = Standard deviation of post-experimental group S_2 = Standard deviation of post-control group
$d. = \dfrac{\sum_{\mathbf{i=1}}^{\mathbf{k}}(\boldsymbol{d}_{\mathbf{i}}\boldsymbol{w}_{\mathbf{i}})}{\sum_{\mathbf{i=1}}^{\mathbf{k}}\boldsymbol{w}_{\mathbf{i}}}$	$w_i = \dfrac{\mathbf{2}(\boldsymbol{n}_{\mathbf{i1}} + \boldsymbol{n}_{\mathbf{i2}})\boldsymbol{n}_{\mathbf{i1}}\,\boldsymbol{n}_{\mathbf{i2}}}{\mathbf{2}(\boldsymbol{n}_{\mathbf{i1}} + \boldsymbol{n}_{\mathbf{i2}})^{\mathbf{2}} + \boldsymbol{n}_{\mathbf{i1}}\,\boldsymbol{n}_{\mathbf{i2}}\boldsymbol{d}_{\mathbf{i}}{}^{\mathbf{2}}}$

Table 5 Cohen's effect size analysis method

Effect size	Value
Small effect size	ESsm ≤ 0.20
Moderate effect size	ESsm = 0.50
Large effect size	ESsm ≥ 0.80

Note. ESsm, the effect size of standardized mean difference

Table 6 *Q* statistics and Higgins *I*^{2} calculation formula

Calculation formula	
$Q = \sum_{\mathbf{i-1}}^{\mathbf{k}} \boldsymbol{W}_{\mathbf{i}}\,(\boldsymbol{Y}_{\mathbf{i}} - \boldsymbol{M})^{\mathbf{2}}$	Q =Homogeneity test statistic Y_i =Individual study M = Pooled mean k = Number of included studies
$I^2 = \left(\dfrac{\mathbf{Q} - \boldsymbol{df}}{\mathbf{Q}}\right) \times \mathbf{100}\%$	$df = k-1$, degree of freedoms k =Number of included studies

8. Ethical consideration

This study was conducted in accordance with the ethical principles outlined in the Declaration of Helsinki, Bioethics and Safety Act and any other relevant ethical laws. According to the Bioethics and Safety Act article 11690 article 15 paragraph 2-3, a study on the utilization of existing data or documents for research subjects is subject to an exemption from the ethics committee. Thus, this study was reviewed and received an approval for the Request for Exemption from the Institutional Review Board (IRB) of the Seoul National University (SNUIRB-2019-NH-002) (Appendix 3). In addition, the systematic review protocol was prospectively registered in the PROSPERO registry, an international database for the prospective registration of systematic reviews in health and social care (protocol available online at www.crd.york.ac.uk/pospero/) through the Centre for Reviews and Dissemination at the University of York, Heslington, York, United Kingdom to eliminate unplanned duplication of the current study. This prospective protocol registration has allowed carefully planning the review by anticipating potential problems, having clear inclusion and exclusion criteria for the data extraction process to prevent any arbitrary decision makings, and, most importantly, to reduce selective reporting bias risks (Moher et al., 2009). This study was registered and conducted under a PROSPERO code number (CRD42019122024). This study received no specific funding from both internal and external sources.

CHAPTER V. RESULTS

1. Study selection

The literature search using electronic databases resulted in 23,353 references from 4 databases and additional sources. After removing 20,297 duplicates, 3,093 search results remained. Of these, titles and abstracts of 2,952 references did not meet the predefined inclusion criteria and were excluded. Original full-text articles were obtained for the remaining 141 search results. Of these, 114 references were excluded with reasons (Appendix 9). We further identified 1 additional study from reviewing reference lists of the retrieved full-text articles. Hence, this review included 28 articles published between 1995 and 2019 (Appendix 8). Of these, 20 with sufficient statistical data were included in the quantitative synthesis (Figure 2).

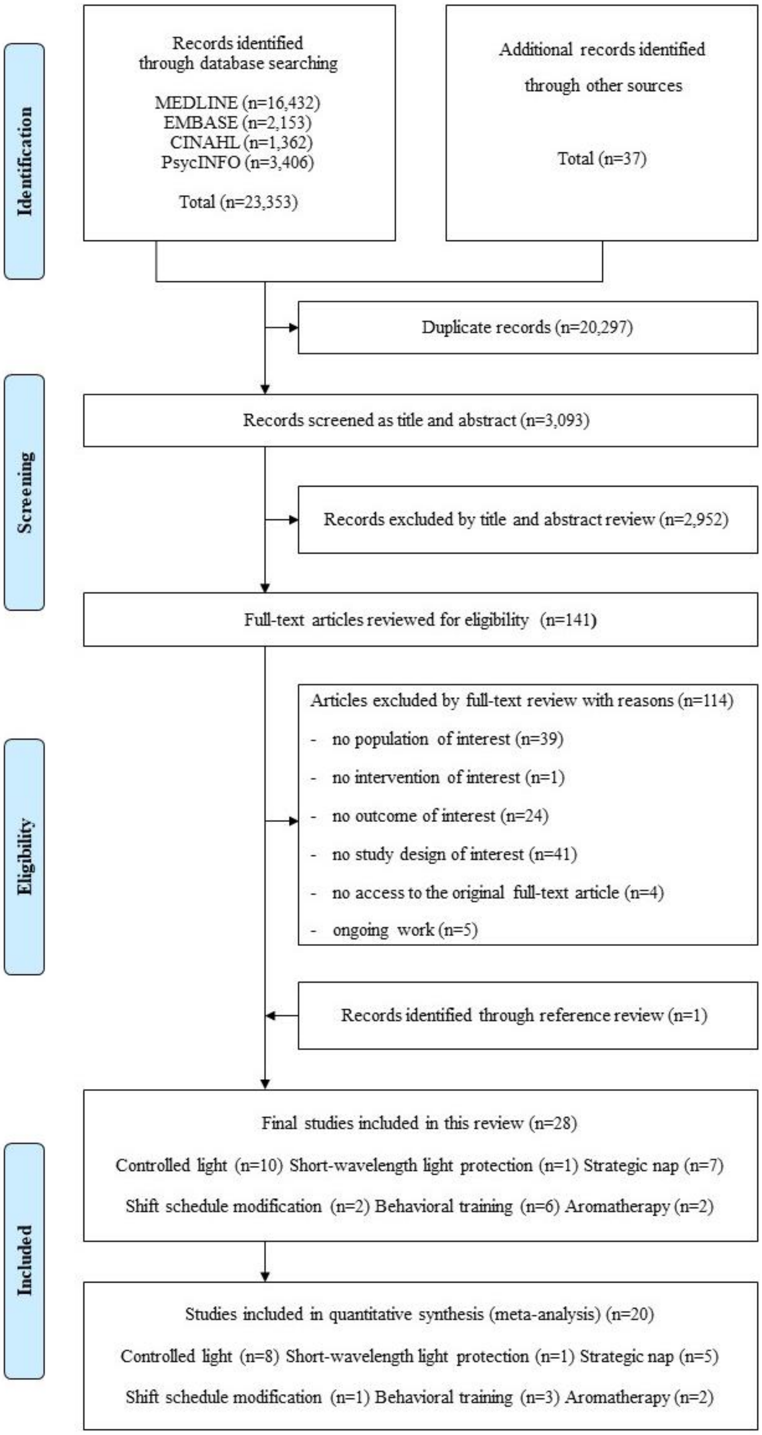


Figure 2 PRISMA flow diagram

2. General description of included studies

Studies included a total of 2,483 workers with 1,795 male and 573 female subjects. Two studies failed to indicate the sex of 115 subjects (Y. S. Chang et al., 2015; Pylkkonen et al., 2018). Twelve trials were conducted on both genders (Bjorvatn et al., 2007; Griepentrog, Labiner, Gunn, & Rosengart, 2018; Howard, Radford, Jackson, Swann, & Kennedy, 2010; Jarnefelt et al., 2012; W. Kim & Hur, 2016; K. A. Lee, Gay, & Alsten, 2014; Lowden, Akerstedt, & Wibom, 2004; Rahman et al., 2013; Scott, Hofmeister, Rogness, & Rogers, 2010; Sletten et al., 2017; Sullivan et al., 2017), 9 on males only (Harma et al., 2006; Karchani, Kakooei, Yazdi, & Zare, 2011; Ross, Arendt, Horne, & Haston, 1995; Sadeghniiat-Haghighi, Yazdi, Jahanihashemi, & Aminian, 2011; Sallinen, Harma, Akerstedt, Rosa, & Lillqvist, 1998; Smith-Coggins et al., 2006; Smith-Coggins, Rosekind, Buccino, Dinges, & Moser, 1997; Thorne, Hampton, Morgan, Skene, & Arendt, 2010; Viitasalo, Kuosma, Laitinen, & Harma, 2008) and 5 on females only (Chang, Lin, & Chang, 2017; Huang, Tsai, Chen, & Hsu, 2013; Oriyama, Miyakoshi, & Kobayashi, 2014; Tanaka et al., 2011; Zion & Shochat, 2019). These studies were conducted in 12 different countries including 5 Asia & Pacific countries, 5 European countries and 2 North American countries. They were conducted largely on healthcare workers (n=14, 50.0%), industrial or manufacturing workers (n=6, 21.4%) and workers in various other industries (n=8, 28.6%).

Within the retained studies, 6 non-pharmacological interventions were identified. Of the final studies, 11 consisted of controlled lighting with 10 focusing on exposing subjects to bright lights (Bjorvatn et al., 2007; Griepentrog et al., 2018; Huang et al., 2013; Karchani et al., 2011; Lowden et al., 2004; Ross et al., 1995; Sadeghniiat-Haghighi et al., 2011; Sletten et al., 2017; Tanaka et al., 2011; Thorne et al., 2010) and 1 on protecting from bright lights during the night hours (Rahman et al., 2013). Strategic naps were implemented in 7 trials (Y. Chang et al., 2015; Howard et al., 2010; Oriyama et al., 2014; Sallinen et al., 1998; Smith-Coggins et al., 2006; S. C. Smith, S. Kilby, G. Jorgensen, & J. A. Douglas, 2007; Zion & Shochat, 2019). The effect of shift schedule modification was examined in 2 studies (Harma et al., 2006; Viitasalo et al., 2008), and behavioral trainings to promote alertness, sleep and fatigue prevention were found in 6 studies (Jarnefelt et al., 2012; K. A. Lee et al., 2014; Pylkkonen et al., 2018; Scott et al., 2010; Smith-Coggins et al., 1997; Sullivan et al., 2017). Also, 2 trials using aromatherapy with essential oils were identified (Chang et al., 2017; W. Kim & Hur, 2016) (Table 4).

3. Non-pharmacological interventions

1) Controlled light exposure

Ten trials investigated the effect of bright light exposure alone (Bjorvatn et al., 2007; Griepentrog et al., 2018; Huang et al., 2013; Karchani et al., 2011; Lowden et al., 2004; Ross et al., 1995; Sadeghniiat-Haghighi et al., 2011; Sletten et al., 2017; Tanaka et al., 2011; Thorne et al., 2010) (Table 7). In total, these trials reviewed the effect of controlled light exposure on 519 participants. Controlled cross-over design was used in seven trials (Bjorvatn et al., 2007; Griepentrog et al., 2018; Karchani et al., 2011; Lowden et al., 2004; Sadeghniiat-Haghighi et al., 2011; Tanaka et al., 2011; Thorne et al., 2010, and the standard parallel design was used in three studies (Huang et al., 2013; Ross et al., 1995; Sletten et al., 2017). Studies were conducted in various industries including healthcare setting (n=3) (Griepentrog et al., 2018; Huang et al., 2013; Tanaka et al., 2011), industrial or manufacturing settings (n= 5) (Bjorvatn et al., 2007; Karchani et al., 2011; Lowden et al., 2004; Sadeghniiat-Haghighi et al., 2011; Thorne et al., 2010), geophysical research center (n= 1) (Ross et al., 1995) and at an unspecified workplace (n= 1) (Sletten et al., 2017).

The delivery method, range of duration and intensity of controlled light varied between studies. Controlled light exposure was administered using a light box (Bjorvatn et al., 2007; Huang et al., 2013; Lowden et al., 2004; Sadeghniiat-Haghighi et al., 2011; Sletten et al., 2017; Tanaka et al., 2011; Thorne et al., 2010) or fluorescent ceiling bulbs or tubes in the employee work stations or break rooms (Griepentrog et al., 2018; Karchani et al., 2011). One study did not state the delivery method of controlled light exposure (Ross et al., 1995). Individual sessions ranged in length from 10 minutes to 10 hours, and the maximum light intensity for a single session varied between 750 to 10,000 lux. Most of the interventions provided one session per day (Bjorvatn et al., 2007; Huang et al., 2013; Ross et al., 1995; Tanaka et al., 2011; Thorne et al., 2010), and the intervention duration ranged from 4 days to 3 months.

Different measures were used to report the outcomes of interest. Sleepiness on-shift (n= 7) (Bjorvatn et al., 2007; Karchani et al., 2011; Lowden et al., 2004; Ross et al., 1995; Sadeghniiat-Haghighi et al., 2011; Sletten et al., 2017; Tanaka et al., 2011), sleep length off-shift (n=5) (Bjorvatn et al., 2007; Griepentrog et al., 2018; Lowden et al., 2004; Sletten et al., 2017; Thorne et al., 2010), and sleep quality off-shift (n=7) (Bjorvatn et al., 2007; Huang et al., 2013; Lowden et al., 2004; Ross et al., 1995; Sletten et al., 2017; Tanaka et al., 2011; Thorne et al., 2010) were reported using both objective and subjective measures. The most widely used tools in this intervention group included the Karolinska Sleepiness Scale (KSS), the Stanford Sleepiness Scale (SSS), sleep diary and actigraphy.

The impact of controlled light exposure on sleep disturbances was judged favorable for 8 of 10 studies (Griepentrog et al., 2018; Huang et al., 2013; Karchani et al., 2011; Lowden et al., 2004; Ross et al., 1995; Sadeghniiat-Haghighi et al., 2011; Tanaka et al., 2011; Thorne et al., 2010). Among the three sleep disturbance aspects, bright light exposure was shown to have a significantly positive effect on reducing sleepiness on-shift (Griepentrog et al., 2018; Huang et al., 2013; Karchani et al., 2011; Lowden et al., 2004; Sadeghniiat-Haghighi et al., 2011; Tanaka et al., 2011). (Appendix 6). On the other hand, the effect of controlled light exposure on sleep disturbances off-shift was shown to have conflicting results. Although light exposure significantly increased sleep length off-shift and increased sleep quality by reducing sleep onset period in one study (Thorne et al., 2010), other studies did not find any significant effect (Bjorvatn et al., 2007; Ross et al., 1995; Sletten et al., 2017).

2) Short-wavelength light protection

One parallel designed trial investigated the effect of short-wavelength light protection on sleep disturbances (Rahman et al., 2013) (Table 7). Nine nurses were enrolled in an 8-week trial that explored the effect of wearing glasses fitted with short-wavelength filters during the entire night work hours. The comparison group was exposed to regular unfiltered ambient artificial light during the same hours. Both groups were exposed to a mean light intensity of 179.4 ± 48.3 lux with the exposure group wearing glasses fitted with polycarbonate lenses coated with thin-film filters that block all light wave transmission (0% transmission) below 480 nm of length (Rahman et al., 2013).

Participants were assessed on for subjective and objective sleep disturbances. Sleepiness on-shift was measured via Epworth Sleepiness Scale (ESS), and sleep length and sleep quality off-shift were evaluated with daily sleep diaries and polysomnography (PSG) data (Appendix 5).

This trial reported that the short-wavelength light protection significantly increased sleep length and quality off-shift. The use of optical filters showed a significant improvement in objective sleep parameters including increased total sleep time, reduced wake after sleep onset (WASO) and reduced sleep onset latency. However, the intervention did not show any significant changes in sleepiness on-shift (Rahman et al., 2013).

3) Strategic naps

Seven trials investigating the effect of strategic naps on disturbed sleep were identified (Y. Chang et al., 2015; Howard et al., 2010; Oriyama et al., 2014; Sallinen et al., 1998; Smith-Coggins et al., 2006; S. C. Smith et al., 2007; Zion & Shochat, 2019) (Table 7). Cross-over designed trials (n= 4) (Howard et al., 2010; Sallinen et al., 1998; S. C. Smith et al., 2007; Zion & Shochat, 2019) and parallel designed trials (n= 3) (Y. Chang et al., 2015; Oriyama et al., 2014; Smith-Coggins et al., 2006) were conducted on a total of 268 participants, who were mostly working in healthcare settings (Y. Chang et al., 2015; Oriyama et al., 2014; Smith-Coggins et al., 2006; S. C. Smith et al., 2007; Zion & Shochat, 2019).

Duration and timing of the nap interventions varied among studies. Most studies implemented a single session of nap for 30 to 40 minutes (n= 5). Two trials explored the effect of two naps within one-night work period (Howard et al., 2010; Oriyama et al., 2014). All trials, except for one, compared the intervention group with night workers with no nap. In the one exceptional study, controlled nap exposure group was compared with both night workers with no nap and also with day workers with no nap (Y. Chang et al., 2015).

Studies showed conflicting results in regards to the effect of strategic nap intervention on three types of sleep disturbances. Some reported significantly positive effect on improving sleep (Smith-Coggins et al., 2006; S. C. Smith et al., 2007; Zion & Shochat, 2019), whereas no significant effect was observed four studies (Y. Chang et al., 2015; Howard et al., 2010; Oriyama et al., 2014; Sallinen et al., 1998) (Appendix 6). The conflicting results were apparent for sleepiness on-shift. Three studies showed significant improvement in sleepiness on-shift in participants who received naps during the night work hours compared to those who did not (Smith-Coggins et al., 2006; S. C. Smith et al., 2007; Zion & Shochat, 2019). However, other four studies did not find any marked differences (Y. Chang et al., 2015; Howard et al., 2010; Oriyama et al., 2014; Sallinen et al., 1998). As for sleep length off-shift and sleep quality off-shift, study uniformly reported no significant effect (Smith-Coggins et al., 2006; S. C. Smith et al., 2007; Zion & Shochat, 2019).

4) Shift schedule modification

Two trials exploring effects of shift schedule modification on sleep were identified (Harma et al., 2006; Viitasalo et al., 2008) (Table 7). Both studies had the standard parallel design, and were conducted on 221 male maintenance personnel working a continuous backward-rotating three-shift system at an airline company in Finland (Harma et al., 2006; Viitasalo et al., 2008). Trials investigated effects of modifying 8-hr backward-rotating schedule to an 8-hr (Viitasalo et al., 2008) or a 10-hr (Harma et al., 2006; Viitasalo et al., 2008) rapid forward-rotating schedule. The comparator group kept the preliminary 8-hr backward-rotating schedule. The modified schedule was maintained for 1 year in one study (Viitasalo et al., 2008) and for 2 years in another (Harma et al., 2006).

Both studies showed that the rapid forward-rotating schedule significantly improved the perceived alertness on-shift, which represents decreased sleepiness on-shift. Both studies included subjective measures in assessing sleepiness on-shift. One study obtained data using ESS and the Basic Nordic Sleep Questionnaire (BNSQ) (Viitasalo et al., 2008), and the other study used KSS and sleep diary (Harma et al., 2006). Sleep duration off-shift was assessed using wrist-worn actigraphy in one study (Harma et al., 2006). Objective sleep improvement in relation to the shift schedule modification was shown only among the younger age participants (Appendix 6).

5) Behavioral training

We included six trials that investigated the effect of behavioral training interventions on the outcomes of interest (Jarnefelt et al., 2012; K. A. Lee et al., 2014; Pylkkonen et al., 2018; Scott et al., 2010; Smith-Coggins et al., 1997; Sullivan et al., 2017) (Table 7). All six trials were randomized controlled trials with standard parallel design, but incorporated heterogeneous behavioral training programs. Two studies based their programs on cognitive behavioral therapies (Jarnefelt et al., 2012; K. A. Lee et al., 2014), whereas the others used programs to relieve fatigue and to promote sleep (Pylkkonen et al., 2018; Scott et al., 2010; Smith-Coggins et al., 1997; Sullivan et al., 2017). Except for one study, the experimental group received face-to-face lectures (Jarnefelt et al., 2012; Pylkkonen et al., 2018; Scott et al., 2010; Smith-Coggins et al., 1997; Sullivan et al., 2017).

Sleep length off-shift and sleep quality off-shift were examined as the outcome measures. Three studies provided with sufficient objective data for meta-analysis on sleep length off-shift (Jarnefelt et al., 2012; K. A. Lee et al., 2014; Smith-Coggins et al., 1997). These studies concluded that the interventions have an increasing effect on sleep. However, the other three studies that were excluded from the quantitative synthesis did not find any significant effect (Appendix 6) (Pylkkonen et al., 2018; Smith-Coggins et al., 1997; Sullivan et al., 2017).

6) Aromatherapy

Two trials with standard parallel design evaluated the effects of aromatherapy on night workers' subjective and objective sleep measures (Chang et al., 2017; W. Kim & Hur, 2016) (Table 7). A total of 110 participants in healthcare settings were included. Although both trials used aromatherapy, the details of the interventions differed from one another. One study used *Origanum majorana* with massage technique (Chang et al., 2017), whereas the other used *Lavendula augustifolia* with inhalation method (W. Kim & Hur, 2016). However, both studies provided aromatherapy after night work hours prior to sleep, and assessed for sleep duration and sleep quality off-shift subjectively and objectively. Both studies reported significantly positive effect of the aromatherapy on improving sleep quality off-shift among night workers in healthcare settings (Appendix 6).

Table 7 Summary of included studies

Controlled light exposure								
No	**Study**	**Study design**	**Population**	**Intervention**	**Comparison**	**Outcome**		
	First author **Publication year** **Country**		**Sample size** **Industry** **Sex** **Age (range or mean age(SD))** **Night work hours**	**Intervention (*N*)**	**Control (*N*)**	**Sleep disturbance type**	**Outcome measures**	**Effect of intervention on sleep**
1	Bjorvatn* 2007 Norway	Randomized cross-over	17 Oil rig Both (M16:F1) 49-55 years 18:30-06:30	10,000 lux, 30-min per exposure, 1 exposure per night, 8-night period (17)	Standard light during night work (17)	1, 2, 3	(S) KSS, ATS scale, sleep diary (O) Actig	No impact
2	Griepentro* 2018 USA	Randomized cross-over	43 Healthcare Both (M21: F22) 26-32 years 19:00-07:00	2,000 lux, 10-hr per exposure, 1 continuous exposure per night, 28-night period (43)	Standard ambient fluorescent light during night work (43)	1	(S) SSS	Favorable
3	Huang 2013 Taiwan	RCT	102 Healthcare Female NR 22:00-07:00	10,000 lux, 30-min per exposure, 1 exposure per night, 10-night period (46)	Standard 100-400 lux light during night work (56)	1	(S) ISI	Favorable
4	Karchani* 2011 Iran	Randomized cross-over	90 Metal production Male 30-36 years 22:00-06:00	3,000 lux, 15-min per exposure, 4 exposures per night, 2-night period (90)	Standard 300 lux light during night work and during breaks (90)	1	(S) SSS	Favorable
5	Lowden* 2004 Sweden	Randomized cross-over	18 Truck production Both (M16:F2) 24-56 years 36.2(3.0) 00:00-06:30	2,500 lux, 10-min per exposure, 2 exposures per night, 15-night period (18)	Standard 300 lux light during night work and during breaks (18)	1, 2, 3	(S) KSS, KSD, sleep diary (O) Actig	Favorable

6	Ross 1995 UK	RCT	13 Geophysical research Male 21-35 years 20:00-08:00	3,000 lux, 2-hr per exposure, 1 exposure per night, 7-night period (7)	Dim 500 lux red light for 2-hr during night work and standard light during night work (5)	1, 2, 3	(S) Sleep diary, VAS	Favorable
7	Sadeghniiat-Haghighi* 2011 Iran	Randomized cross-over	94 Ceramic factory Male 21-45 years 18:00-06:00	2,500 lux, 20-min per exposure, 2 exposures per night, 1-night period (94)	Standard 300 lux light during night work and during breaks (94)	1	(S) SSS	Favorable
8	Sletten* 2017 Australia	RCT	71 NR Both (M42:F29) 32.8(10.5) 22:00-08:00	750 lux blue-enriched white light, 8-hr per exposure, 1 continuous exposure per night, 7~14-night period (36)	Standard spectrum white light during night work (35)	1, 2, 3	(S) KSS, KDT (O) Actig, PSG	No impact
9	Tanaka* 2011 Japan	Randomized cross-over	61 Healthcare Female 20-60 years 29.7(8.6) 18:30-08:30	8,826 lux, 10-min per exposure, 1 exposure per day, 30-night period (61)	Standard light exposure in a windowless environment during night work (61)	1, 2, 3	(S) KSS, VAS, sleep diary	Favorable
10	Thorne* 2010 UK	Randomized cross-over	10 Oil rig Male 46(11) 19:00-07:00	3,000 lux, 60-min per exposure, 1 exposure per night, 35-night period (10)	Standard light during night work (10)	2 ,3	(S) Sleep diary (O) Actig	Favorable
Short-wavelength light protection								
1	Rahman* 2013 Canada	RCT	9 Healthcare Both (4M: 5F) 31.3(4.6) 19:30-07:30	12-hr light protection, glasses with fitted filter (0% transmission <480 nm) for 24-night period (4)	Exposure to standard unfiltered ambient artificial light during night work (5)	1, 2, 3	(S) ESS, Sleep diary (O) PSG	Favorable

Strategic naps								
1	Chang 2015 Taiwan	RCT	63 Healthcare NR 26.1(1.9) 00:00-08:00	30-min per exposure, 1 exposure per night, between 19:00-23:00 or 02:00-03:00, 1-night period (21)	No nap during night work (21)	1	(S) SSS	No impact
2	Howard* 2010 Australia	Randomized cross-over	8 Sleep research Both (2M: 6F) 24-54 years 31.0(9.6) 21:00-07:00	30-min per exposure, 1 exposure per night, at 04:00, 1-night period (8)	No nap during night work, minimum of 7-hr sleep on the night prior to the session (8)	1	(S) KSS	No impact
3	Oriyama 2014 Japan	RCT	15 Healthcare Female 23.71(1.88) 00:00-08:45	15-min per exposure, 2 exposures per night, between 02:30-03:00, 04:30-05:45, 1-night period (8)	No nap during night work (7)	1	(S) VAS	No impact
4	Sallinen* 1998 USA	Randomized cross-over	14 Oil rig Male 31-52 years 23:00-07:10	30 or 50-min per exposure, 1 exposure per night, at 01:00 or 04:10, 1-night period (14)	No nap during night work (14)	1	(S) KSS	No impact
5	Smith* 2007 Australia	Randomized cross-over	9 Healthcare Both (M3: 6F) 45.7(13.2) 20:30-07:00	30-min per exposure, 1 exposure per night, between 02:00-03:00, 1-night period (9)	No nap and no corresponding break during night work (9)	2, 3	(O) PSG	Favorable
6	Smith-Coggins* 2006 USA	RCT	49 Healthcare Male NR 19:30-07:30	40-min per exposure, 1 exposure per night, between 03:00-04:00, 1-night period (49)	No nap during night work (49)	1, 2	(S) KSS (O) Actig	Favorable
7	Zion* 2019 Israel	Randomized cross-over	110 Healthcare Female 23-63 23:00-07:00	30-min per exposure, 1 exposure per night, at 04:00, 4-night period (110)	No nap during night work (110)	1, 2, 3	(S) PSQI, PSAS, KSS (O) Actig	Favorable

Shift schedule modification								
1	Harma* 2006 Finland	RCT	137 Airline company Male 24-61 years 23:00-08:00	10-hr rapid forward-rotating schedule for 6-month period (24)	8-hr backward-rotating schedule (113)	1, 2, 3	(S) KSS, sleep diary (O) Actig	Favorable
2	Viitasalo 2008 Finland	RCT	84 Airline company Male 27-58 23:00-07:00	8-hr or 10-hr rapid forward-rotating schedule for 12-month period (62)	8-hr backward-rotating schedule (22)	1	(S) BNSQ, ESS	Favorable
Behavioral training								
1	Jarnefelt* 2012 Finland	RCT	26 Broadcasting company Both (M13: F13) 43.5(8.4) 22:00-07:30	Cognitive behavioral therapy for insomnia, 3-month period ▪ Seven 90 to 120-min face-to-face group lecture ▪ 50-min face-to-face individual lecture (12)	No behavioral training (14)	2, 3	(S) Sleep diary (O) Actig	Favorable
2	Lee* 2014 USA	RCT	21 Healthcare Both (M1: F20) 24-67 45.5(12.5) NR	Cognitive behavioral therapy-based sleep enhancement training, 42-day period ▪ Sleep enhancement training guideline booklet ▪ Sound-enhanced relaxation training (21)	No behavioral training (21)	2, 3	(S) PSQI, GDDS, SSI, sleep diary (O) Actig	Favorable
3	Pylkkonen 2018 Finland	RCT	52 Domestic logistic companies NR NR NR	Alertness management training, 362-day period ▪ Two 45-min face-to-face lectures ▪ 60-min workshop ▪ Tailored advice session (31)	No behavioral training (21)	1	(S) KSS	No impact

4	Scott* 2010 USA	RCT	62 Healthcare Both (M2: F60) 22-63 37.75(11.70) NR	Fatigue countermeasure, 30-month period ▪ 60-min face-to-face lecture ▪ Tailored work schedule during exposure period (32)	No behavioral training (30)	1, 2, 3	(S) PSQI, ESS, sleep diary	Favorable
5	Smith-Coggins* 1997 USA	RCT	6 Healthcare Male NR 00:00-08:00	Fatigue countermeasure, sleep promotion, alertness promotion training, 1-month period ▪ 120-min face-to-face lecture ▪ Tailored work schedule during exposure period (3)	No behavioral training (3)	2, 3	(S)Sleep diary, SSS (O) PSG	No impact
6	Sullivan 2017 USA	RCT	1189 Fire department Both (M1173: F16) 22-72 43.6(7.4) 23:00-07:00	Sleep Health Program, 54-week period ▪ 30-min face-to-face lecture ▪ Voluntary sleep disorder screening ▪ Sleep disorders diagnosis and treatment for those at risk (601)	No behavioral training (588)	1, 2, 3	(S) AIS	No impact
Aromatherapy								
1	Chang* 2017 Taiwan	RCT	50 Healthcare Female 23-48 NR	60-min inhalation and massage exposure, 4 total exposures, 1-month period, *Origanum majorana* (27)	No aromatherapy (23)	3	(S) PSQI (O) ECG detector	Favorable
2	Kim* 2016 Korea	RCT	60 Healthcare Both (M5: F55) 20-60 23:00-07:00	3-min inhalation exposure, 3 total exposures, 3-day period, *Lavendula augustifolia* (30)	No aromatherapy (30)	2, 3	(S) NRS, VSH (O) Actig	Favorable

Note. Studies were organized in alphabetical order; *, studies included in the quantitative synthesis (meta-analysis). Details of each study author's conclusion is included in Appendix 7. *Acronyms.* SD, standard deviation; *N*, number of participants; M, male; F, female; (S), subjective; 1, sleepiness on-shift; 2, sleep length off-shift; 3, sleep quality off-shift; KSS, Karolinska Sleepiness Scale; ATS scale, Accumulated Time with Sleepiness scale; (O), objective; Actig, Actigraphy; SSS, Stanford Sleepiness scale; RCT, randomized controlled trial; NR, not reported; ISI, Insomnia Severity Index; KSD, Karolinska Sleep Diary; VAS, Visual Analogue Scale; KDT, Karolinska Drowsiness Test; PSG, polysomnography; ESS, Epworth Sleepiness Scale; PSQI, Pittsburgh Sleep Quality Index; PSAS, Pre-Sleep Arousal Scale; BNSQ, Basic Nordic Sleep Questionnaire; DBAS, Dysfunctional Beliefs and Attitudes about Sleep; GDS, General Sleep Disturbance Scale; AIS, Athens Insomnia Scale; NRS, Numeric Rating Scale; VSH, Verran & Snyder-Halpern sleep scale; No impact, intervention had no significant effect on sleep disturbance improvement; Favorable, intervention had significant effect on sleep disturbance improvement

4. Risk of bias within the included studies

The risk of bias percentages across all included studies and the risk of bias summary and judgements about each risk of bias domain visually illustrated (Figure 3 & Figure 4). Overall, all of the included studies had some type of risk of bias especially in relation to performance and detection biases. Most of the studies raised concerns due to failure to report how they masked study participants and/or outcome assessors. According to the Cochrane RoB criteria and the standards of most recently published meta-analysis studies, none of the included studies was considered as having low risk of bias (J. Higgins et al., 2016; J. P. Higgins et al., 2011; Lam et al., 2019; Larsen, Christensen, Juhl, Andersen, & Langberg, 2019). The detailed RoB judgments and support for judgements for each domain is presented for all included studies in the data extraction form (Appendix 6).

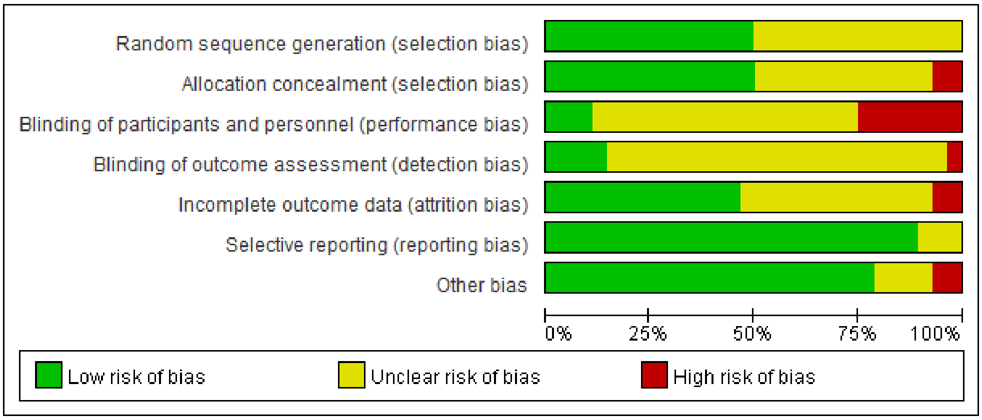


Figure 3 Risk of bias graph

judgements about each risk of bias item presented as percentages across included studies

Figure 4 Risk of bias summary

judgements about each risk of bias item for each included study

Note. +, Low risk of bias; ?, Unclear risk of bias with some concerns; −, High risk of bias

5. Quantitative synthesis results

A total of 20 studies involving 959 participants that examined the effects of non-pharmacological interventions on sleep disturbances in night workers were included in the meta-analysis (Bjorvatn et al., 2007; Chang et al., 2017; Griepentrog et al., 2018; Harma et al., 2006; Howard et al., 2010; Jarnefelt et al., 2012; Karchani et al., 2011; W. Kim & Hur, 2016; K. A. Lee et al., 2014; Lowden et al., 2004; Rahman et al., 2013; Sadeghniiat-Haghighi et al., 2011; Sallinen et al., 1998; Scott et al., 2010; Sletten et al., 2017; Smith-Coggins et al., 2006; S. S. Smith et al., 2007; Tanaka et al., 2011; Thorne et al., 2010; Zion & Shochat, 2019) (Table 8). The remaining 8 studies were excluded due to insufficient statistical data for standard mean difference and pooled effect size calculations (Y. Chang et al., 2015; Huang et al., 2013; Oriyama et al., 2014; Pylkkonen et al., 2018; Ross et al., 1995; Smith-Coggins et al., 1997; Sullivan et al., 2017; Viitasalo et al., 2008).

The 20 studies indicated the pooled effect size of non-pharmacological interventions on sleep disturbances of -1.61(SMD = −1.61; 95% CI −2.51 to −0.72) with statistical significance (Z = 3.53, p = 0.0004). However, studies showed a large heterogeneity (Higgins I^2 = 98%) (Figure 5). We assumed that this was due to heterogeneous assessment measures and result reports of sleep disturbances, and, therefore, the subgroup quantitative syntheses of the interventions were conducted according to the outcome-based, comparison-based and occupation-based results of the 20 studies.

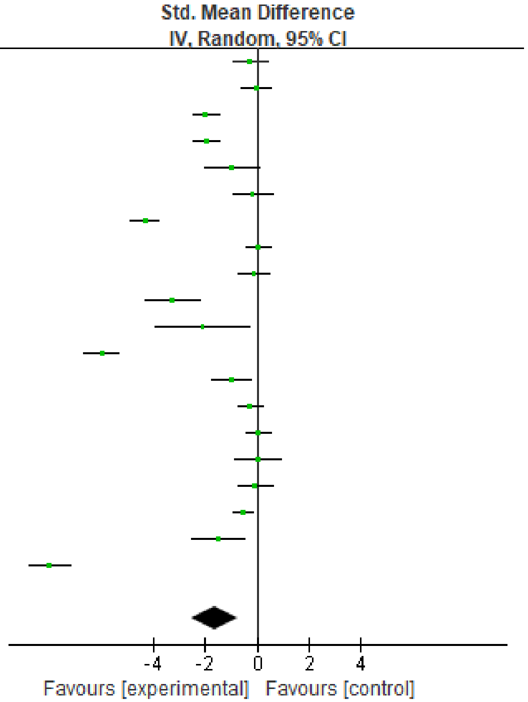
For the outcome-based meta-analyses, we were able to perform 7 syntheses according to the types of sleep disturbances: sleepiness on-shift, sleep length off-shift and sleep quality off-shift. For outcome measures, we only selected those that had more than 2 trials using the same measures. As for the comparison-based results, we attempted to perform meta-analyses on the 6 identified non-pharmacological interventional methods. However, we were not able to perform meta-analyses on the effect of short-wavelength light protection due to having only one study, and on the effects of shift schedule modification and aromatherapy due to heterogeneous outcome measures. Thus, we analyzed the pooled effects of 3 interventions: controlled light exposure, strategic naps and behavioral training. The occupation of included subjects were categorized into healthcare, industrial or manufacturing and others for the subgroup analysis. The forest plots of overall pooled estimated effect sizes and subgroup effect sizes for each synthesis were visually illustrated. Because all results were expressed in continuous data, inverse variance method was used with standardized mean difference effect measures. The random effects model was chosen for all analytic syntheses.

Figure 5 The effect of non-pharmacological interventions on sleep disturbances

Study or Subgroup	Experimental Mean	Experimental SD	Experimental Total	Control Mean	Control SD	Control Total	Weight	Std. Mean Difference IV, Random, 95% CI
Bjorvatn 2007	-6.98	1.05	17	-6.72	1	17	5.1%	-0.25 [-0.92, 0.43]
Chang 2017	7.53	2.22	27	7.58	1.92	23	5.1%	-0.02 [-0.58, 0.53]
Griepentrog 2018	2.6	0.2	43	3	0.2	43	5.1%	-1.98 [-2.50, -1.46]
Harma 2006	-6.3	0.51	24	-5.7	0.24	113	5.1%	-1.97 [-2.47, -1.47]
Howard 2010	4.91	0.57	8	6.06	1.45	8	4.9%	-0.99 [-2.04, 0.07]
Jarnefelt 2012	-7.2	0.6	12	-7.1	0.5	14	5.0%	-0.18 [-0.95, 0.60]
Karchani 2011	2.02	0.58	90	4.8	0.69	90	5.1%	-4.34 [-4.88, -3.80]
Kim 2016	-6.93	1.42	30	-7.02	1.35	30	5.1%	0.06 [-0.44, 0.57]
Lee 2014	-8.06	1.42	21	-7.92	1.07	21	5.1%	-0.11 [-0.71, 0.50]
Lowden 2004	-7.38	0.21	18	-6.74	0.17	18	4.9%	-3.28 [-4.31, -2.24]
Rahman 2013	-7.3	0.24	4	-6.63	0.31	5	4.3%	-2.11 [-3.96, -0.26]
Sadeghniiat-Haghighi 2011	2.43	0.12	94	3.07	0.09	94	5.1%	-6.01 [-6.69, -5.33]
Sallinen 1998	-90.3	3.8	14	-73.7	22.6	14	5.0%	-0.99 [-1.79, -0.20]
Scott 2010	7.65	2.54	32	8.35	2.7	30	5.1%	-0.26 [-0.76, 0.24]
Sletten 2017	-5.6	1.4	36	-5.7	1.55	35	5.1%	0.07 [-0.40, 0.53]
Smith 2007	7.8	5.69	9	7.61	4.58	9	4.9%	0.04 [-0.89, 0.96]
Smith-Coggins 2006	-7.31	2.39	49	-7.16	2.39	10	5.1%	-0.06 [-0.74, 0.62]
Tanaka 2011	3.74	1.01	61	4.29	1.01	61	5.2%	-0.54 [-0.90, -0.18]
Thorne 2010	-6.75	0.5	10	-5.76	0.73	10	4.9%	-1.52 [-2.54, -0.49]
Zion 2019	3.6	0.16	110	4.89	0.16	110	5.0%	-8.03 [-8.84, -7.23]
Total (95% CI)			**709**			**755**	**100.0%**	**-1.61 [-2.51, -0.72]**

Heterogeneity: $Tau^2 = 4.01$; $Chi^2 = 775.60$, $df = 19$ ($P < 0.00001$); $I^2 = 98\%$

Test for overall effect: $Z = 3.53$ ($P = 0.0004$)



Note. Forest plot of non-pharmacological interventions on sleep disturbances. For studies that provided with both subjective and objective data, we used objective outcome data in the meta-analysis. In order to accommodate for the correct direction of x-axis for the objective total sleep time measures, we multiplied the mean and standard deviation values by -1.

1) Outcome-based analyses

1-1) Effect on sleepiness on-shift

A total of 8 studies that provided adequate statistical data were included in calculating the pooled effect size of non-pharmacological interventions on sleepiness on-shift. It showed that the experimental group that received non-pharmacological interventions had a reduction effect of –2.83 (SMD = –2.83; 95% CI –4.55 to –1.10), and showed a statistically significant difference to the control group (Z = 3.20, p = 0.001). However, the heterogeneity between groups showed high heterogeneity (Higgins I^2 = 99%). Therefore, we performed subgroup analysis based on the outcome measures: KSS and SSS (Figure 6).

Due to high heterogeneity (Higgins I^2 = 99%) among the five studies that measured sleepiness on-shift using KSS, random effects model was chosen for the calculation. Although it showed that non-pharmacological interventions had a reduction effect of –2.05 (SMD = –2.05; 95% CI –4.18 to 0.07) based on KSS assessments, no statistical significance was found between the experimental and control groups (Z = 1.89, p = 0.06). Similarly, studies that investigated sleepiness on-shift based on SSS scores had high heterogeneity (Higgins I^2 = 98%). However, it showed that the interventions reduced SSS-measured sleepiness on-shift by –4.10 (SMD = –4.10; 95% CI –6.35 to –1.86) with statistical significance (Z = 3.58, p = 0.0003).

In the primary meta-analysis, it was shown that non-pharmacological interventions may aid in improving sleepiness on-shift measured by SSS. In order to verify whether this result also applies to KSS measurement, we further conducted a sensitive analysis for the KSS subgroup by removing one study that had significantly heterogeneous result (Zion & Shochat, 2019). The sensitive analysis result showed that interventions also had a significant effect on reducing KSS-based subjective sleepiness on-shift as well (Appendix 10).

1-2) Effect on sleep length off-shift

Eleven studies investigated non-pharmacological interventions' effect on sleep length off-shift using objective actigraphy or polysomnography. The sleep length off-shift were reported as total sleep hours in units of either hours or minutes. For the analytic purposes, results that were reported in minutes were converted to hour units by multiplying $\frac{1\ hour}{60\ minutes}$. Although high heterogeneity was found between studies (Higgins I^2 = 88%), pooled effect calculation showed that the non-pharmacological interventions have an increasing effect of 0.76 hours on objective total sleep time (SMD = 0.76; 95% CI 0.15 to 1.37) with statistical significance (Z = 2.45, $p = 0.01$) (Figure 7). Due to high heterogeneity, we further conducted subgroup analyses based on the outcome measures: actigraphy and polysomnography.

The total sleep hours were measured using wrist-worn actigraphy in nine studies, whereas the other two used polysomnography. The actigraphy results showed high heterogeneity (Higgins I^2 = 90%), and showed the interventions to have an increasing effect on workers' total sleep hours by 0.75 (SMD = 0.75; 95% CI 0.08 to 1.42) with statistical significance (Z = 2.19, $p = 0.03$) (Figure 7, 1.2.1). Polysomnography study results had borderline moderate heterogeneity (Higgins I^2 = 74%), but indicated statistically insignificant increasing effect of interventions on total sleep hours (SMD = 0.91; 95% CI –1.10 to 2.92; Z = 0.89, $p = 0.37$) (Figure 7, 1.2.2).

1-3) Effect on sleep quality off-shift

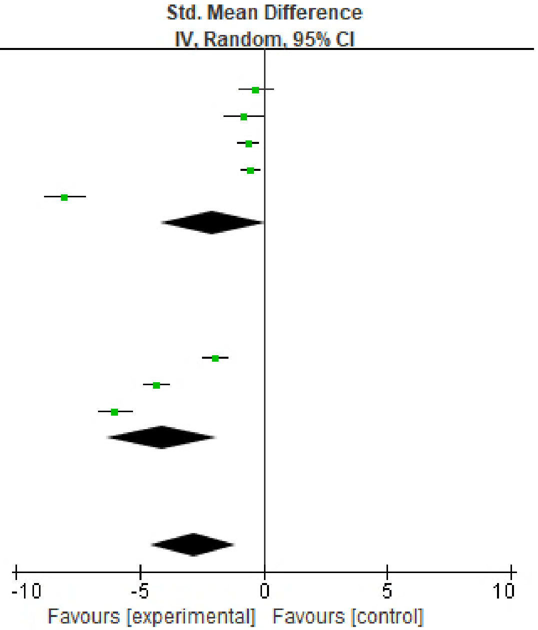
The sleep quality off-shift included both subjective and objective measures including the PSQI, sleep diary, actigraphy and polysomnography. However, each instrument had its own interpretation of sleep disturbance. For studies that used PSQI, we included the global PSQI score for this meta-analysis, sleep quality score for sleep dairy and sleep onset latency for actigraphy and polysomnography data, respectively. A total of eight studies were included in this analysis with some studies providing more than one outcome measures. The study results had fairly low heterogeneity (Higgins I^2 = 36%), and showed non-pharmacological interventions to have a favorable effect on sleep quality off-shift (SMD = –0.57; 95% CI –0.81 to –0.34) with statistical significance (Z = 4.82, $p < 0.00001$) (Figure 8). Since the outcome measures were based on scales where higher scores represent worse sleep quality, the negative value of pooled effect is translated as having a favorable effect on the sleep quality.

Subgroup analyses were performed based on the outcome measures. Studies that used subjective outcome measures showed statistically insignificant results. The PSQI tool showed moderate heterogeneous (Higgins I^2 = 57%) and statistically insignificant results (SMD = –0.35; 95% CI –0.85 to 0.14, Z = 1.41, $p = 0.16$) (Figure

8, 1.3.1). Sleep diaries showed homogeneous results (Higgins $I^2 = 0\%$), but indicated statistical insignificance (SMD = –0.32; 95% CI –0.76 to 0.13, Z = 1.41, $p = 0.16$) (Figure 8, 1.3.2). On the other hand, objective outcome measures indicated non-pharmacological interventions to have a statistically significant effect on increasing sleep quality off-shift. The sleep onset latency results were homogeneous (Higgins $I^2 = 0\%$) with statistically significant effect (SMD = –0.63; 95% CI –1.00 to –0.25, Z = 3.28, $p = 0.001$) (Figure 8, 1.3.3). Studies in which objective sleep efficiency were reported showed moderate heterogeneity (Higgins $I^2 = 62\%$), but showed statistically significant effect (SMD = –0.90; 95% CI –1.48 to –0.32, Z = 3.06, $p = 0.002$) (Figure 8, 1.3.4).

Figure 6 The effect of non-pharmacological interventions on sleepiness on-shift

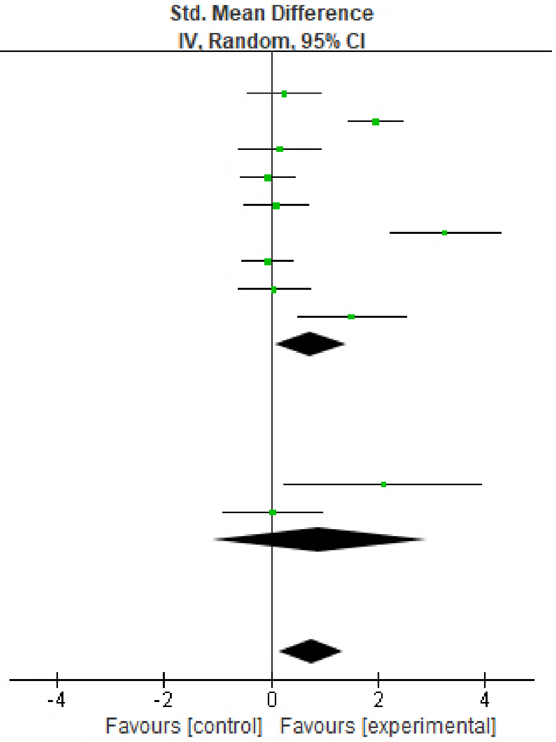
Study or Subgroup	Experimental Mean	Experimental SD	Experimental Total	Control Mean	Control SD	Control Total	Weight	Std. Mean Difference IV, Random, 95% CI
1.1.1 Sleepiness on-shift: KSS								
Bjorvatn 2007	4	0.8	17	4.3	1	17	12.5%	-0.32 [-1.00, 0.35]
Sallinen 1998	6.9	1.8	14	8.2	1.2	14	12.4%	-0.83 [-1.60, -0.05]
Smith-Coggins 2006	5.36	1.78	49	6.48	1.78	49	12.6%	-0.62 [-1.03, -0.22]
Tanaka 2011	3.74	1.01	61	4.29	1.01	61	12.6%	-0.54 [-0.90, -0.18]
Zion 2019	3.6	0.16	110	4.89	0.16	110	12.4%	-8.03 [-8.84, -7.23]
Subtotal (95% CI)			**251**			**251**	**62.4%**	**-2.05 [-4.18, 0.07]**
Heterogeneity: Tau² = 5.79; Chi² = 306.53, df = 4 (P < 0.00001); I² = 99%								
Test for overall effect: Z = 1.89 (P = 0.06)								
1.1.2 Sleepiness on-shift: SSS								
Griepentrog 2018	2.6	0.2	43	3	0.2	43	12.6%	-1.98 [-2.50, -1.46]
Karchani 2011	2.02	0.58	90	4.8	0.69	90	12.5%	-4.34 [-4.88, -3.80]
Sadeghniiat-Haghighi 2011	2.43	0.12	94	3.07	0.09	94	12.5%	-6.01 [-6.69, -5.33]
Subtotal (95% CI)			**227**			**227**	**37.6%**	**-4.10 [-6.35, -1.86]**
Heterogeneity: Tau² = 3.85; Chi² = 91.70, df = 2 (P < 0.00001); I² = 98%								
Test for overall effect: Z = 3.58 (P = 0.0003)								
Total (95% CI)			**478**			**478**	**100.0%**	**-2.83 [-4.55, -1.10]**
Heterogeneity: Tau² = 6.12; Chi² = 563.31, df = 7 (P < 0.00001); I² = 99%								
Test for overall effect: Z = 3.20 (P = 0.001)								
Test for subgroup differences: Chi² = 1.69, df = 1 (P = 0.19), I² = 40.7%								



Note. Forest plot of non-pharmacological interventions on sleepiness on-shift according to the outcome measures (non-pharmacological intervention vs. no intervention). *Acronyms*. KSS, The Karolinska Sleepiness Scale; SSS, the Stanford Sleepiness Scale

Figure 7 The effect of non-pharmacological interventions on sleep length off-shift

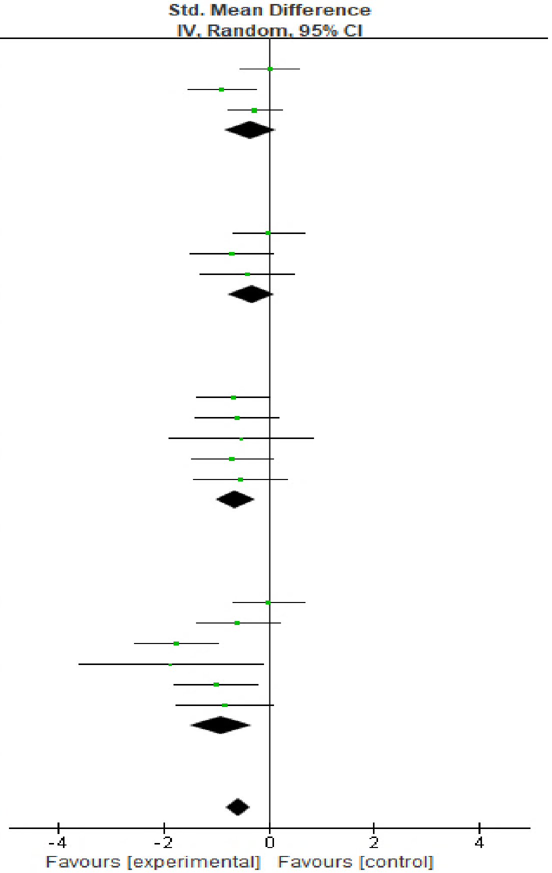
Study or Subgroup	Experimental Mean	Experimental SD	Experimental Total	Control Mean	Control SD	Control Total	Weight	Std. Mean Difference IV, Random, 95% CI
1.2.1 Sleep length off-shif: Actig								
Bjorvatn 2007	6.98	1.05	17	6.72	1	17	9.6%	0.25 [-0.43, 0.92]
Harma 2006	6.3	0.51	24	5.7	0.24	113	10.2%	1.97 [1.47, 2.47]
Jarnefelt 2012	7.2	0.6	12	7.1	0.5	14	9.3%	0.18 [-0.60, 0.95]
Kim 2016	6.93	1.42	30	7.02	1.35	30	10.2%	-0.06 [-0.57, 0.44]
Lee 2014	8.06	1.42	21	7.92	1.07	21	9.9%	0.11 [-0.50, 0.71]
Lowden 2004	7.38	0.21	18	6.74	0.17	18	8.3%	3.28 [2.24, 4.31]
Sletten 2017	5.6	1.4	36	5.7	1.55	35	10.3%	-0.07 [-0.53, 0.40]
Smith-Coggins 2006	7.31	2.39	49	7.16	2.39	10	9.6%	0.06 [-0.62, 0.74]
Thorne 2010	6.75	0.5	10	5.76	0.73	10	8.4%	1.52 [0.49, 2.54]
Subtotal (95% CI)			**217**			**268**	**85.8%**	**0.75 [0.08, 1.42]**
Heterogeneity: Tau² = 0.93; Chi² = 79.01, df = 8 (P < 0.00001); I² = 90%								
Test for overall effect: Z = 2.19 (P = 0.03)								
1.2.2 Sleep length off-shift: PSG								
Rahman 2013	7.3	0.24	4	6.63	0.31	5	5.4%	2.11 [0.26, 3.96]
Smith 2007	7.8	5.69	9	7.61	4.58	9	8.7%	0.04 [-0.89, 0.96]
Subtotal (95% CI)			**13**			**14**	**14.2%**	**0.91 [-1.10, 2.92]**
Heterogeneity: Tau² = 1.60; Chi² = 3.87, df = 1 (P = 0.05); I² = 74%								
Test for overall effect: Z = 0.89 (P = 0.37)								
Total (95% CI)			**230**			**282**	**100.0%**	**0.76 [0.15, 1.37]**
Heterogeneity: Tau² = 0.88; Chi² = 82.95, df = 10 (P < 0.00001); I² = 88%								
Test for overall effect: Z = 2.45 (P = 0.01)								
Test for subgroup differences: Chi² = 0.02, df = 1 (P = 0.88), I² = 0%								



Note. Forest plot of non-pharmacological interventions on sleep length off-shift measured via actigraphy and polysomnography (non-pharmacological intervention vs. no intervention). The sleep length off-shift was measured as total sleep time in hours. For studies that reported results in minutes were calculated to hour units. *Acronyms*. Actig, actigraphy; PSG, polysomnography

Figure 8 The effect of non-pharmacological interventions on sleep quality off-shift

Study or Subgroup	Experimental Mean	Experimental SD	Experimental Total	Control Mean	Control SD	Control Total	Weight	Std. Mean Difference IV, Random, 95% CI
1.3.1 Sleep quality off-shift: PSQI								
Chang 2017	7.63	2.22	27	7.58	1.92	23	8.7%	0.02 [-0.53, 0.58]
Lee 2014	5.48	3.34	21	8.1	2.32	21	7.5%	-0.89 [-1.53, -0.26]
Scott 2010	7.65	2.54	32	8.35	2.7	30	9.6%	-0.26 [-0.76, 0.24]
Subtotal (95% CI)			**80**			**74**	**25.7%**	**-0.35 [-0.85, 0.14]**
Heterogeneity: Tau² = 0.11; Chi² = 4.63, df = 2 (P = 0.10); I² = 57%								
Test for overall effect: Z = 1.41 (P = 0.16)								
1.3.2 Sleep quality off-shift: Sleep diary								
Bjorvatn 2007	3.1	0.7	17	3.1	0.7	17	7.1%	0.00 [-0.67, 0.67]
Jarnefelt 2012	1.5	0.6	12	1.9	0.5	14	5.7%	-0.71 [-1.51, 0.09]
Thorne 2010	4.6	1.2	10	5.1	1.2	10	4.9%	-0.40 [-1.29, 0.49]
Subtotal (95% CI)			**39**			**41**	**17.7%**	**-0.32 [-0.76, 0.13]**
Heterogeneity: Tau² = 0.00; Chi² = 1.80, df = 2 (P = 0.41); I² = 0%								
Test for overall effect: Z = 1.41 (P = 0.16)								
1.3.3 Sleep quality off-shift: Actig & PSG (SOL)								
Bjorvatn 2007	9	5	17	14	9	17	6.8%	-0.67 [-1.36, 0.02]
Jarnefelt 2012	16.3	12.6	12	29	25.5	14	5.8%	-0.60 [-1.39, 0.19]
Rahman 2013	10.59	1.89	4	13.27	5.76	5	2.5%	-0.53 [-1.88, 0.83]
Sallinen 1998	3.6	2.1	14	6.9	6.2	14	6.0%	-0.69 [-1.46, 0.07]
Thorne 2010	12.6	10.2	10	22.8	23.4	10	4.8%	-0.54 [-1.44, 0.36]
Subtotal (95% CI)			**57**			**60**	**25.9%**	**-0.63 [-1.00, -0.25]**
Heterogeneity: Tau² = 0.00; Chi² = 0.11, df = 4 (P = 1.00); I² = 0%								
Test for overall effect: Z = 3.28 (P = 0.001)								
1.3.4 Sleep quality off-shift: Actig & PSG (SE)								
Bjorvatn 2007	-86	9	17	-86	6	17	7.1%	0.00 [-0.67, 0.67]
Jarnefelt 2012	-91	5	12	-87.3	6.9	14	5.8%	-0.59 [-1.38, 0.20]
Lowden 2004	-90.4	0.5	18	-89.5	0.5	18	5.8%	-1.76 [-2.54, -0.98]
Rahman 2013	-85.94	3.32	4	-78.14	4.01	5	1.6%	-1.86 [-3.60, -0.12]
Sallinen 1998	-90.3	3.8	14	-73.7	22.6	14	5.7%	-0.99 [-1.79, -0.20]
Thorne 2010	-86.7	5.8	10	-79.4	10.3	10	4.6%	-0.84 [-1.76, 0.09]
Subtotal (95% CI)			**75**			**78**	**30.7%**	**-0.90 [-1.48, -0.32]**
Heterogeneity: Tau² = 0.31; Chi² = 13.14, df = 5 (P = 0.02); I² = 62%								
Test for overall effect: Z = 3.06 (P = 0.002)								
Total (95% CI)			**251**			**253**	**100.0%**	**-0.57 [-0.81, -0.34]**
Heterogeneity: Tau² = 0.08; Chi² = 25.03, df = 16 (P = 0.07); I² = 36%								
Test for overall effect: Z = 4.82 (P < 0.00001)								
Test for subgroup differences: Chi² = 3.19, df = 3 (P = 0.36), I² = 5.9%								



Note. Forest plot of non-pharmacological interventions on sleep quality off-shift according to the outcome measures (non-pharmacological intervention vs. no intervention). The sleep onset latency was measured in minutes. The sleep efficiency was measured in percentages. For 1.3.4. subgroup, we multiplied the mean sleep efficiency values by -1 to match the left and right graph labels. *Acronyms*. Actig, actigraphy; PSG, polysomnography; SOL, sleep onset latency; SE, sleep efficiency.

2) Comparison-based analyses

2-1) Effect of controlled light exposure

Among 10 studies that investigated the effect of controlled light exposure on sleep disturbances, 7 provided with sufficient statistical data for meta-analytic synthesis (Bjorvatn et al., 2007; Griepentrog et al., 2018; Karchani et al., 2011; Lowden et al., 2004; Sadeghniiat-Haghighi et al., 2011; Sletten et al., 2017; Thorne et al., 2010). These studies compared the sleep disturbances between night workers who received bright light versus those who did not. Sleepiness on-shift was reported using subjective SSS in three studies, whereas sleep length and sleep quality off-shift were reported using objective actigraphy and polysomnography measures in four studies. Although these study results were highly heterogeneous (Higgins $I^2 = 97\%$) and thus should be interpreted in caution, the controlled light exposure was shown to have a significantly favorable effect on sleep disturbance (SMD = –1.62; 95% CI –2.81 to –0.43, Z = 2.67, $p = 0.008$) (Figure 9).

Subgroup analyses were conducted according to the assessment methods. Only subjective measure indicated significantly positive effect of controlled light exposure on sleepiness on-shift (SMD = –4.10; 95% CI –6.35 to –1.86, Z = 3.58, $p = 0.0003$) with high heterogeneity (Higgins $I^2 = 98\%$) (Figure 9, 2.1.1). The objective measures intervention's effect on total sleep time, sleep onset latency and sleep efficiency reported insignificant results (SMD = –1.18; 95% CI –2.50 to 0.14, Z = 1.75, $p = 0.08$; SMD = 0.15; 95% CI –0.39 to 0.68, Z = 0.54, $p = 0.59$; SMD = –0.84; 95% CI –1.79 to 0.11, Z = 1.4, $p = 0.08$) (Figure 9, 2.1.2.; Figure 9, 2.1.3.; Figure 9, 2.1.4., respectively).

2-2) Effect of strategic naps

Five studies were included for the meta-analytic synthesis for investigating pooled effect of strategic naps on sleepiness on-shift and sleep length off-shift (Howard et al., 2010; Sallinen et al., 1998; Smith-Coggins et al., 2006; S. S. Smith et al., 2007; Zion & Shochat, 2019). Overall, the study results showed high heterogeneity (Higgins $I^2 = 98\%$), and strategic naps did not show any significant effect on sleep disturbances (SMD = –1.73; 95% CI –4.00 to 0.55, Z = 1.49, p = 0.14) (Figure 10).

Subgroup analyses based on the assessment methods did not indicate significant effect of strategic naps on sleep disturbances. The sleepiness on-shift, measured by KSS, showed a tendency to decrease with strategic naps by 2.62, but the result was not significant (SMD = –2.62; 95% CI –6.00 to 0.77, Z = 1.51, p = 0.13) (Figure 10, 2.2.1). Objectively measured sleep length off-shift also did not show any significant result (SMD = 0.05; 95% CI –0.50 to 0.60, Z = 0.19, p = 0.85; Higgins $I^2 = 0\%$) (Figure 10, 2.2.2).

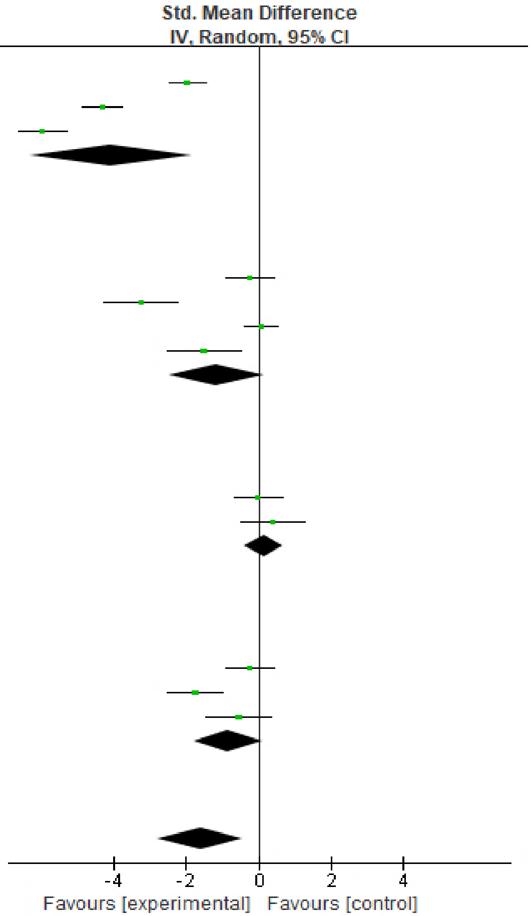
2-3) Effect of behavioral training

Four studies were included for the meta-analytic synthesis for investigating pooled effect of behavioral training on sleep length and sleep quality off-shift (Jarnefelt et al., 2012; K. A. Lee et al., 2014; Scott et al., 2010; Smith-Coggins et al., 1997). Although these studies were calculated to be fairly homogenous (Higgins I^2 = 17%), the pooled effect of the intervention did not show any significant effect on sleep disturbances (SMD = –0.30; 95% CI –0.64 to 0.03, Z = 1.77, p = 0.08) (Figure 11).

Despite the low heterogeneity, subgroup analyses were conducted to investigate possibilities for significantly positive effect of behavioral trainings for sleep disturbance types. However, no significant effect was found for both sleep length and sleep quality off-shift (SMD = –0.04; 95% CI –0.50 to 0.41, Z = 0.19, p = 0.85; SMD = –0.55; 95% CI −1.16 to 0.07, Z = 1.74, p = 0.08) (Figure 11, 2.3.1.; Figure 11, 2.3.2., respectively).

Figure 9 The effect of controlled light exposure on sleep disturbances

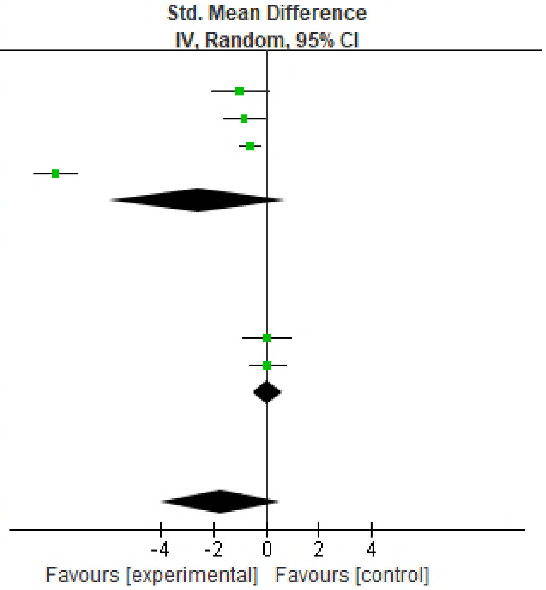
Study or Subgroup	Experimental Mean	Experimental SD	Experimental Total	Control Mean	Control SD	Control Total	Weight	Std. Mean Difference IV, Random, 95% CI
2.1.1 Sleepiness on-shift: SSS								
Griepentrog 2018	2.6	0.2	43	3	0.2	43	8.5%	-1.98 [-2.50, -1.46]
Karchani 2011	2.02	0.58	90	4.8	0.69	90	8.5%	-4.34 [-4.88, -3.80]
Sadeghniiat-Haghighi 2011	2.43	0.12	94	3.07	0.09	94	8.4%	-6.01 [-6.69, -5.33]
Subtotal (95% CI)			**227**			**227**	**25.3%**	**-4.10 [-6.35, -1.86]**
Heterogeneity: Tau² = 3.85; Chi² = 91.70, df = 2 (P < 0.00001); I² = 98%								
Test for overall effect: Z = 3.58 (P = 0.0003)								
2.1.2 Sleep length off-shift: Actig & PSG (TST)								
Bjorvatn 2007	6.72	1	17	6.98	1.05	17	8.4%	-0.25 [-0.92, 0.43]
Lowden 2004	6.74	0.17	18	7.38	0.21	18	8.1%	-3.28 [-4.31, -2.24]
Sletten 2017	5.7	1.5	35	5.6	1.4	36	8.5%	0.07 [-0.40, 0.53]
Thorne 2010	5.76	0.73	10	6.75	0.5	10	8.1%	-1.52 [-2.54, -0.49]
Subtotal (95% CI)			**80**			**81**	**33.1%**	**-1.18 [-2.50, 0.14]**
Heterogeneity: Tau² = 1.64; Chi² = 37.66, df = 3 (P < 0.00001); I² = 92%								
Test for overall effect: Z = 1.75 (P = 0.08)								
2.1.3 Sleep quality off-shift: Actig & PSG (SOL)								
Bjorvatn 2007	6	6	17	6	79.8	17	8.4%	0.00 [-0.67, 0.67]
Thorne 2010	20.4	11.4	10	15.6	11.4	10	8.2%	0.40 [-0.48, 1.29]
Subtotal (95% CI)			**27**			**27**	**16.6%**	**0.15 [-0.39, 0.68]**
Heterogeneity: Tau² = 0.00; Chi² = 0.50, df = 1 (P = 0.48); I² = 0%								
Test for overall effect: Z = 0.54 (P = 0.59)								
2.1.4 Sleep quality off-shift: Actig & PSG (SE)								
Bjorvatn 2007	86	9	17	88	8	17	8.4%	-0.23 [-0.90, 0.45]
Lowden 2004	89.5	0.5	18	90.4	0.5	18	8.3%	-1.76 [-2.54, -0.98]
Thorne 2010	80.6	6.6	10	84.3	6.3	10	8.2%	-0.55 [-1.45, 0.35]
Subtotal (95% CI)			**45**			**45**	**24.9%**	**-0.84 [-1.79, 0.11]**
Heterogeneity: Tau² = 0.54; Chi² = 8.83, df = 2 (P = 0.01); I² = 77%								
Test for overall effect: Z = 1.74 (P = 0.08)								
Total (95% CI)			**379**			**380**	**100.0%**	**-1.62 [-2.81, -0.43]**
Heterogeneity: Tau² = 4.27; Chi² = 401.54, df = 11 (P < 0.00001); I² = 97%								
Test for overall effect: Z = 2.67 (P = 0.008)								
Test for subgroup differences: Chi² = 16.59, df = 3 (P = 0.0009), I² = 81.9%								



Note. Forest plot of controlled light exposure intervention on sleep disturbances (controlled light vs normal light). The total sleep time was measured in hours. The sleep onset latency was measured in minutes. The sleep efficiency was measured in percentages. *Acronyms*. Actig, actigraphy; PSG, polysomnography; TST, total sleep time; SOL, sleep onset latency; SE, sleep efficiency.

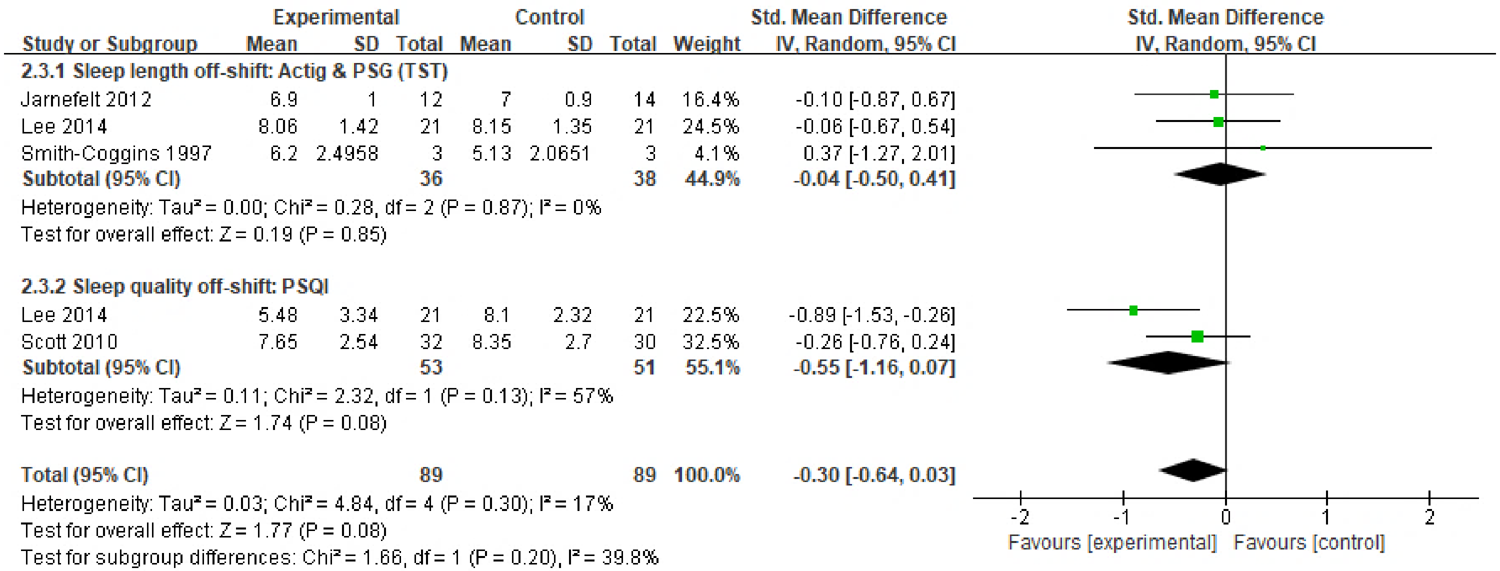
Figure 10 The effect of strategic naps on sleep disturbances

Study or Subgroup	Experimental Mean	Experimental SD	Experimental Total	Control Mean	Control SD	Control Total	Weight	Std. Mean Difference IV, Random, 95% CI
2.2.1 Sleepiness on-shift: KSS								
Howard 2010	4.91	0.57	8	6.06	1.45	8	16.4%	-0.99 [-2.04, 0.07]
Sallinen 1998	6.9	1.8	14	8.2	1.2	14	16.7%	-0.83 [-1.60, -0.05]
Smith-Coggins 2006	5.36	1.793	49	6.48	1.793	49	16.9%	-0.62 [-1.03, -0.21]
Zion 2019	3.6	0.16	110	4.89	0.16	110	16.7%	-8.03 [-8.84, -7.23]
Subtotal (95% CI)			**181**			**181**	**66.7%**	**-2.62 [-6.00, 0.77]**
Heterogeneity: Tau² = 11.76; Chi² = 272.78, df = 3 (P < 0.00001); I² = 99%								
Test for overall effect: Z = 1.51 (P = 0.13)								
2.2.2 Sleep length off-shift: Actig & PSG (TST)								
Smith 2007	7.8	5.69	9	7.61	4.58	9	16.6%	0.04 [-0.89, 0.96]
Smith-Coggins 2006	7.31	2.39	49	7.16	2.39	10	16.8%	0.06 [-0.62, 0.74]
Subtotal (95% CI)			**58**			**19**	**33.3%**	**0.05 [-0.50, 0.60]**
Heterogeneity: Tau² = 0.00; Chi² = 0.00, df = 1 (P = 0.96); I² = 0%								
Test for overall effect: Z = 0.19 (P = 0.85)								
Total (95% CI)			**239**			**200**	**100.0%**	**-1.73 [-4.00, 0.55]**
Heterogeneity: Tau² = 7.93; Chi² = 306.49, df = 5 (P < 0.00001); I² = 98%								
Test for overall effect: Z = 1.49 (P = 0.14)								
Test for subgroup differences: Chi² = 2.33, df = 1 (P = 0.13), I² = 57.0%								



Note. Forest plot of strategic nap intervention on sleep disturbances (strategic naps vs no nap). The total sleep time was measured in hours. *Acronyms*. KSS, the Karolinska Sleepiness Scale; Actig, actigraphy; PSG, polysomnography; TST, total sleep time

Figure 11 The effect of behavioral training on sleep disturbances



Note. Forest plot of behavioral training intervention on sleep disturbances (behavioral training vs no training). The total sleep time was measured in hours. The PSQI global index score was used. *Acronyms*. Actig, actigraphy; PSG, polysomnography; TST, total sleep time; PSQI, the Pittsburgh Sleep Quality Index.

3) Occupation-based analysis

We conducted subgroup analysis based on the occupations: healthcare workers, industrial or manufacturing workers and others including scientists, airline company workers, broadcasting company workers and unspecified workers (Figure 12).

3-1) Healthcare workers

A total of 10 studies were conducted on healthcare workers including nurses and physicians (Chang et al., 2017; Griepentrog et al., 2018; W. Kim & Hur, 2016; K. A. Lee et al., 2014; Rahman et al., 2013; Scott et al., 2010; Smith-Coggins et al., 2006; S. S. Smith et al., 2007; Tanaka et al., 2011; Zion & Shochat, 2019). Most likely due to having varying interventions and outcome measures, the studies were indicated to have high heterogeneity (Higgins $I^2 = 91\%$). However, the interventions showed a significant on sleep disturbances with pooled effect size of -1.28 (SMD = –1.28; 95% CI –2.48 to –0.07, Z = 2.08, $p = 0.04$). (Figure 12, 3.1.1).

3-2) Industrial or manufacturing workers

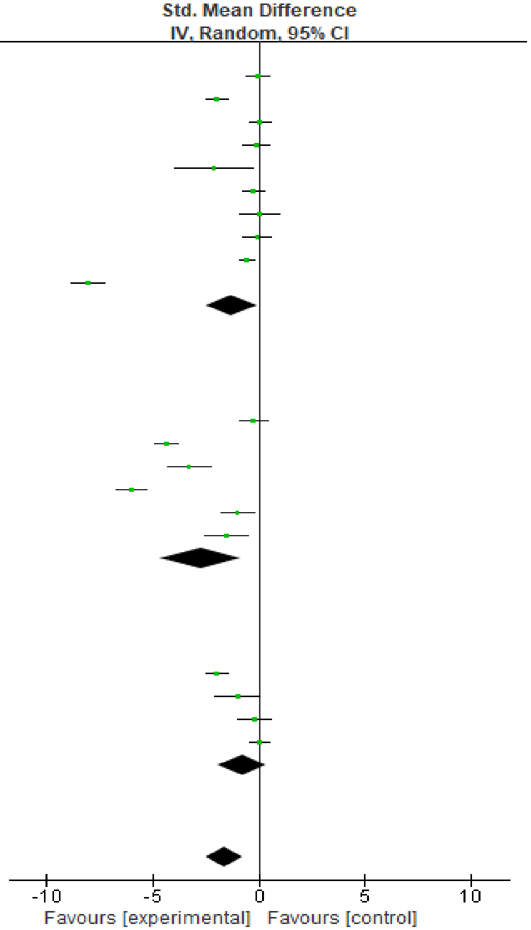
Six studies included workers in industrial or manufacturing settings (Bjorvatn et al., 2007; Karchani et al., 2011; Lowden et al., 2004; Sadeghniiat-Haghighi et al., 2011; Sallinen et al., 1998; Thorne et al., 2010). In this population, the interventions were found to have a significant effect on sleep disturbances (SMD = –2.74; 95% CI –4.65 to –0.83, Z = 2.81, $p = 0.005$; (Higgins $I^2 = 97\%$). (Figure 12, 3.1.2).

3-3) Other workers

The remaining four studies were grouped together and showed the following results: (SMD = –0.77; 95% CI –1.89 to 0.35, Z = 1.34, p = 0.18; (Higgins I^2 =92%). (Figure 12, 3.1.3).

Figure 12 The effect of non-pharmacological interventions on sleep disturbances according to different occupations

	Experimental			Control				Std. Mean Difference
Study or Subgroup	Mean	SD	Total	Mean	SD	Total	Weight	IV, Random, 95% CI
3.1.1 Healthcare								
Chang 2017	7.53	2.22	27	7.58	1.92	23	5.1%	-0.02 [-0.58, 0.53]
Griepentrog 2018	2.6	0.2	43	3	0.2	43	5.1%	-1.98 [-2.50, -1.46]
Kim 2016	-6.93	1.42	30	-7.02	1.35	30	5.1%	0.06 [-0.44, 0.57]
Lee 2014	-8.06	1.42	21	-7.92	1.07	21	5.1%	-0.11 [-0.71, 0.50]
Rahman 2013	-7.3	0.24	4	-6.63	0.31	5	4.3%	-2.11 [-3.96, -0.26]
Scott 2010	7.65	2.54	32	8.35	2.7	30	5.1%	-0.26 [-0.76, 0.24]
Smith 2007	7.8	5.69	9	7.61	4.58	9	4.9%	0.04 [-0.89, 0.96]
Smith-Coggins 2006	-7.31	2.39	49	-7.16	2.39	10	5.1%	-0.06 [-0.74, 0.62]
Tanaka 2011	3.74	1.01	61	4.29	1.01	61	5.2%	-0.54 [-0.90, -0.18]
Zion 2019	3.6	0.16	110	4.89	0.16	110	5.0%	-8.03 [-8.84, -7.23]
Subtotal (95% CI)			**386**			**342**	**49.9%**	**-1.28 [-2.48, -0.07]**
Heterogeneity: Tau² = 3.61; Chi² = 371.53, df = 9 (P < 0.00001); I² = 98%								
Test for overall effect: Z = 2.08 (P = 0.04)								
3.1.2 Industrial or manufacturing								
Bjorvatn 2007	-6.98	1.05	17	-6.72	1	17	5.1%	-0.25 [-0.92, 0.43]
Karchani 2011	2.02	0.58	90	4.8	0.69	90	5.1%	-4.34 [-4.88, -3.80]
Lowden 2004	-7.38	0.21	18	-6.74	0.17	18	4.9%	-3.28 [-4.31, -2.24]
Sadeghniiat-Haghighi 2011	2.43	0.12	94	3.07	0.09	94	5.1%	-6.01 [-6.69, -5.33]
Sallinen 1998	-90.3	3.8	14	-73.7	22.6	14	5.0%	-0.99 [-1.79, -0.20]
Thorne 2010	-6.75	0.5	10	-5.76	0.73	10	4.9%	-1.52 [-2.54, -0.49]
Subtotal (95% CI)			**243**			**243**	**30.0%**	**-2.74 [-4.65, -0.83]**
Heterogeneity: Tau² = 5.52; Chi² = 196.31, df = 5 (P < 0.00001); I² = 97%								
Test for overall effect: Z = 2.81 (P = 0.005)								
3.1.3 Others								
Harma 2006	-6.3	0.51	24	-5.7	0.24	113	5.1%	-1.97 [-2.47, -1.47]
Howard 2010	4.91	0.57	8	6.06	1.45	8	4.9%	-0.99 [-2.04, 0.07]
Jarnefelt 2012	-7.2	0.6	12	-7.1	0.5	14	5.0%	-0.18 [-0.95, 0.60]
Sletten 2017	-5.6	1.4	36	-5.7	1.55	35	5.1%	0.07 [-0.40, 0.53]
Subtotal (95% CI)			**80**			**170**	**20.1%**	**-0.77 [-1.89, 0.35]**
Heterogeneity: Tau² = 1.17; Chi² = 36.84, df = 3 (P < 0.00001); I² = 92%								
Test for overall effect: Z = 1.34 (P = 0.18)								
Total (95% CI)			**709**			**755**	**100.0%**	**-1.61 [-2.51, -0.72]**
Heterogeneity: Tau² = 4.01; Chi² = 775.60, df = 19 (P < 0.00001); I² = 98%								
Test for overall effect: Z = 3.53 (P = 0.0004)								
Test for subgroup differences: Chi² = 3.05, df = 2 (P = 0.22), I² = 34.5%								



Note. Forest plot of non-pharmacological interventions on sleep disturbances. For studies that provided with both subjective and objective data, we used objective outcome data in the meta-analysis. In order to accommodate for the correct direction of x-axis for the objective total sleep time measures, we multiplied the mean and standard deviation values by -1.

Table 8 Summary of meta-analysis results

Outcome	N	Overall effect				Heterogeneity			
		Hedges' g	95% CI	Effect size	Favors	τ^2	χ^2 (df)	p	I^2
Effect of non-pharmacological interventions on sleep disturbances									
Overall	20	-1.61*	-2.51 to -0.72	Large	Intervention	4.01	775.60 (19)	<0.001	98%
Effect of non-pharmacological interventions on sleep disturbances: Outcome-based analysis									
Sleepiness on-shift									
Overall	8	-2.83*	-4.55 to -1.10	Large	Intervention	6.12	563.31 (7)	0.001	40.7%
(S) KSS	5	-2.05	-4.18 to 0.07	Large	NS	5.79	306.53 (4)	0.06	99%
(S) SSS	3	-4.10*	-6.35 to -1.86	Large	Intervention	3.85	91.70 (2)	<0.001	98%
Sleep length off-shift									
Overall	11	0.76*	0.15 to 1.37	Moderate	Intervention	0.88	8.95 (10)	0.01	88%
(O) Actig—TST (hr)	9	0.75*	0.08 to 1.42	Moderate	Intervention	0.93	79.01 (8)	0.03	90%
(O) PSG—TST (hr)	2	0.91	-1.10 to 2.92	Large	NS	1.60	3.87 (1)	0.37	74%
Sleep quality off-shift									
Overall	9	-0.57*	-0.81 to -0.34	Moderate	Intervention	0.08	25.03 (16)	<0.001	36%
(S) PSQI	3	-0.35	-0.85 to 0.14	Moderate	NS	0.11	4.63 (2)	0.16	57%
(S) Sleep diary	3	-0.32	-0.76 to 0.13	Moderate	NS	0.00	1.80 (2)	0.16	0%
(O) Actig, PSG—SOL (min)	5	-4.00*	-6.42 to -1.57	Large	Intervention	0.00	0.11 (4)	0.001	0%
(O) Actig, PSG—SE (%)	6	-0.90*	-1.48 to -0.32	Large	Intervention	0.31	13.14 (5)	0.002	62%
Effect of controlled light exposure on sleep disturbances: Comparison-based analysis									
Overall	7	-1.62*	-2.81 to -0.43	Large	Intervention	4.27	401.54 (11)	<0.001	97%
Sleepiness on-shift: (S) SSS	3	-4.10*	-6.35 to -1.86	Large	Intervention	3.85	91.70 (2)	<0.001	98%
Sleep length off-shift: (O) Actig, PSG—TST (hr)	4	-1.18	-2.50 to 0.14	Large	NS	1.64	37.66 (3)	0.08	92%
Sleep quality off-shift: (O) Actig, PSG—SOL (min)	2	0.15	-0.39 to 0.68	Small	NS	0.00	0.50 (1)	0.59	0%
Sleep quality off-shift: (O) Actig, PSG—SE (%)	3	-0.84	-1.79 to 0.11	Large	NS	0.54	8.83 (2)	0.08	77%
Effect of strategic naps on sleep disturbances: Comparison-based analysis									
Overall	5	-1.73	-4.00 to 0.55	Large	NS	7.93	306.49 (5)	0.13	98%
Sleepiness on-shift:	4	-2.62	-6.00 to 0.77	Large	NS	11.76	272.78 (3)	0.13	99%

(S) KSS									
Sleep length off-shift: (O) Actig, PSG—TST (hr)	2	0.05	-0.50 to 0.60	Small	NS	0.00	0.00 (1)	0.85	0%
Effect of behavioral training on sleep disturbances: Comparison-based analysis									
Overall	4	-0.30	-0.64 to 0.03	Moderate	NS	0.03	4.84 (4)	0.20	17%
Sleep length off-shift: (O) Actig, PSG —TST (hr)	3	-0.04	-0.05 to 0.41	Small	NS	0.00	0.28 (2)	0.85	0%
Sleep quality off-shift: (S) PSQI	2	-0.55	-1.16 to 0.07	Moderate	NS	0.11	2.32 (1)	0.08	57%
Effect of non-pharmacological interventions on sleep disturbances: Occupation-based analysis									
Overall	20	-1.61*	-1.89 to -0.72	Large	Intervention	4.01	775.60(19)	<0.001	98%
Healthcare	10	-1.28*	-2.48 to -0.07	Large	Intervention	3.61	371.53(9)	<0.001	98%
Industrial or manufacturing	6	-2.74*	-4.65 to -0.83	Large	Intervention	5.52	196.31 (5)	0.005	97%
Others	4	-0.77	-1.89 to 0.35	Moderate	NS	1.17	36.84 (3)	0.18	92%

Note. Results are reported based on random effects model. The absolute values of Hedges' *g* were used for Cohen's effect size analysis. *Acronyms*. *N*, number of studies included in the analysis; *, significant value; CI, confidence interval; τ^2, tau-squared; χ^2,chi-squared (Q statistics); df, degree of freedom; I^2, Higgin's I^2 test; S, Intervention, the intervention is favored over the control in mitigating sleep disturbances; subjective; NS, no significant result; KSS, the Karolinska Sleepiness; SSS, the Stanford Sleepiness Scale; PSQI, the Pittsburgh Sleep Quality Index; O, objective; Actig, actigraphy; PSG, polysomnography; TST, total sleep time; SOL, sleep onset latency; SE, sleep efficiency

CHAPTER VI. DISCUSSION

Minimizing and preventing negative sleep health consequences related to night work is an ongoing challenge, and many have investigated different strategies to improve night workers' sleep. This study aimed to establish the basis of future research and practice guidelines by identifying available non-pharmacological interventions and confirming their effects on reducing sleepiness at work and improving the sleep length and quality between work in night workers. We have identified 6 methods including controlled light exposure, short-wavelength light protection, strategic naps, shift schedule modification, behavioral training and aromatherapy. First, we found that non-pharmacological interventions generally have a significant effect on the sleep disturbances in the expected direction, especially for the sleepiness on-shift. Second, among interventional methods in which we could perform meta-analysis, controlled light exposure was shown to have significant effect. However, we found no significant effect for strategic naps and behavioral training methods. Lastly, non-pharmacological interventions showed significant pooled effect on night workers engaged in healthcare and industrial or manufacturing work.

1. Effect of non-pharmacological interventions on sleep disturbances

Our findings suggest that non-pharmacological interventions in workplace settings to have a positive impact on overall sleep disturbances among night workers. Although the therapeutic effect in mitigating and improving general sleep health was expected, our meta-analysis further provided with evidence that interventions may have varying degrees of effectiveness on sleep disturbances according to 3 types. We observed large effect on sleepiness on-shift compared to moderate effect on sleep length and sleep quality off-shift.

This result may partly due to most of the interventions being provided at the workplace while the participants were carrying out work tasks. Night workers are most often at risk for limited opportunity for sleep recovery and often display sleep restricting behavior off-shift where 2-3 hours of sleep loss per night accumulates over time (Belenky et al., 2003; Chellappa, Morris, & Scheer, 2019). Although the three types of sleep disturbances may develop simultaneously, sleepiness on-shift may be the most prominent problem in night workers with circadian misalignment and extended wakeful periods. Population-based studies have revealed that night workers identified increased subjective sleepiness as the most challenging aspect of the work, and showed subjective sleepiness to have direct effects on decreased cognitive function (Chellappa et al., 2019; Wong, Smith, Ibrahim, Mustard, & Gignac, 2016). These studies found subjective sleepiness to have significantly negative correlations to cognitive performance level, but failed to discover the same association with sleep duration.

Given that the night workers identified sleepiness on-shift as the biggest struggle, interventions that were provided at workplace such as controlled light exposure, short-wavelength light protection, strategic naps, shift schedule modification and aromatherapy may have reflected the strongest therapeutic effect. In accordance with our results, recent meta-analytic reviews conducted on various focus populations, not specific to night workers, have also shown non-pharmacological methods to have a favorable effect on decreasing subjective sleepiness and drowsiness (Chung & Park, 2017; J. H. Kim & Oh, 2016; Slanger et al., 2016). Although a recent review conducted on night workers included laboratory setting studies, it also found strategies to aid in improving sleepiness on-shift (Slanger et al., 2016). Other two reviews which analyzed pooled effects of non-pharmacological strategies on adult population with primary insomnia, also showed significant therapeutic effect on increasing daytime alertness and sleep quality, but showed insignificant results for total sleep time (Chung & Park, 2017; J. H. Kim & Oh, 2016).

2. Effect of controlled light exposure on sleep disturbances

Among interventions, the controlled light exposure showed statistically significant therapeutic effect, whereas strategic naps and behavioral training did not. We suggest a few plausible explanations for the differential interventional effects of controlled light exposure, strategic naps and behavioral training.

The significant effect of controlled light exposure on sleep disturbances is likely to be associated with its direct effect on melatonin hormone secretion and circadian rhythm regulation. Light is considered the main external cue that acts as a human time keeper influencing sleep and wakefulness mediated partly by melatonin suppression (Jensen et al., 2016; Lunn et al., 2017). Although understanding sleep disturbances in night workers is highly complex, it is generally thought to be due to periodic or chronic circadian disruption that was built over the entire night work period and over the years of employment. Based on the rationale that the timing of light and darkness determines the internal clock rhythm and affects sleep behavior, controlled light exposure has been investigated in multiple groups of people with sleep problems. A recent review study, which investigated the effect of light therapy on various types of sleep disorders including circadian rhythm sleep disorders, insomnia, sleep problems related to Alzheimer's disease and dementia, has shown light therapy to be most effective on sleep problems related to circadian rhythm disruption (van Maanen et al., 2016). Our study result is likely to be due to sufficient intensity and duration of bright light exposure at night hours causing a shift in the timing and amplitude of the melatonin signals and delaying the nadir phase. Thus, controlled light therapy in night workers with circadian misalignment is likely to have shifted their circadian rhythms and subsequently increased the ability to adapt to working and being awake during the night hours (Griepentrog et al., 2018; Huang et al., 2013; Karchani et al., 2011; Sadeghniiat-Haghighi et al., 2011).

3. Effect of strategic naps on sleep disturbances

Our analysis showed that strategic nap interventions to be statistically insignificant on mitigating sleep disturbances. Several factors may have contributed to this insignificant result.

First, majority of the included studies defined night and day hours according to civil time measures and failed to consider individual chronobiological time measures. Chronotypes refer to individual expressions of circadian rhythmicity and is classified as morning type, intermediate type and evening type depending on the individual's biologically preferred time measures of activities and sleep (Fang, Huang, Wu, Wu, & Tsai, 2018; Östberg, 1973). A few past studies have also raised concerns in relation to conducting sleep research on night workers and suggested that individual chronobiology should be taken into consideration (Erren & Grobeta, 2015; M. Leung et al., 2016). Workers with morning chronotypes are less likely to tolerate working during night hours compared to evening counterparts (Erren, 2013; Reinke, Ozbay, Dieperink, & Tulleken, 2015; Roenneberg, Wirz-Justice, & Merrow, 2003; Uzoigwe & Sanchez Franco, 2018). When individual chronobiological propensities including physiology, endocrinology, metabolism and behaviors are not carefully evaluated, civil and biological time scales of night and day hours may not correspond each other. Thus, observed effect interventions on sleep outcome measures may not well translate and may mislead to false positive or false negative estimates. A mismatch between active working hours and chronotype can lead to severe sleep disturbances, which may not be fully relieved by nap opportunities taken during the work hours, especially for morning type individuals and may require multiple strategies. Also, studies with large number of morning chronotypes may have muted potentially positive effect of strategic naps on sleep measures due to lack of consideration to their biological preference to specific hours of activity.

Another factor that may have contributed to the ineffective result is sleep inertia, which is defined as a brief period of decreased cognitive and performance functions immediately following a period of sleep (Hilditch, Dorrian, Centofanti, Van Dongen, & Banks, 2017; Ruggiero & Redeker, 2014). Most of the included studies assessed participants' sleepiness on-shift after providing them with nap opportunities. Due to a lack of agreement in the literature to the exact time frame of sleep inertia, it is still unclear to determine the optimal time of sleep assessment after naps are taken. However, studies have shown sleep inertia to last as long as 30 minutes (Kubo et al., 2010; Ruggiero & Redeker, 2014). Thus, it may be that the participants in the included studies may have been assessed prior to fully recovering from sleep inertia, and thereby reporting insignificant results. One of the included studies, which was not a part of the meta-analysis due to insufficient statistical data, surprisingly showed that the nap condition group to have worse subjective sleep quality compared to the control group (Sallinen et al., 1998). The author also proposed that perhaps sleep inertia and ineffective timing of assessment may have contributed to this outcome. Hence, five strategic nap studies included in our meta-analysis may have resulted in only marginal significant effect on sleepiness on-shift and insignificant effect on sleep length off-shift due to a failure to address individual chronotypes and sleep inertia.

4. Effect of behavioral training on sleep disturbances

Behavioral training did not show a significant effect on sleep disturbance improvement, and only a marginal effect was indicated on sleep quality off-shift. Based on the results of previous studies, we postulate the following aspects to be associated with the insignificant outcome.

The smaller improvements in objective total sleep time compared with subjective sleep quality are most likely to be associated with the techniques and methods used in the behavioral training interventions. Most of the included studies provided with individual or group face-to-face lectures on sleep and alertness enhancement and fatigue management, which aimed to achieve stimulus control and sleep restriction. The goal of these interventions were to limit fragmented sleep opportunities to slowly increase the sleep drive. Previous meta-analysis studies and workplace-based studies were also consistent with our findings and indicated behavioral sleep interventions to result in more immediate improvements in subjective sleep quality and wakefulness-in-bed and delayed improvement in total sleep time (Blake, Sheeber, Youssef, Raniti, & Allen, 2017; Koffel, Koffel, & Gehrman, 2015; Schiller, Soderstrom, Lekander, Rajaleid, & Kecklund, 2018).

Based on this rationale, the behavioral training strategies may require longer duration of exposure and follow-up to fully assess objective changes in sleep. Our pooled effect of behavioral training interventions on objective sleep was based on studies that were conducted for a relatively short duration, ranging from 1 to 3-month periods (Jarnefelt et al., 2012; K. A. Lee et al., 2014; Smith-Coggins et al., 1997). Although it is difficult to determine the optimal duration of intervention exposure and follow-up period for night workers based on our review, previous RCT and review studies have suggested that behavioral therapies may be more effective on total sleep time when participants are followed for at least 6-month period (Bathgate, Edinger, & Krystal, 2017; Schiller et al., 2018). Additionally, cohort studies and reviews have shown behavioral training programs to demonstrate a significantly positive effect on dysfunctional attitudes and beliefs about sleep (Eidelman et al., 2016; J. H. Kim & Oh, 2016; Wright, Bogan, & Wyatt, 2013). Perhaps behavioral training that is provided for shorter duration may be more useful in raising sleep health awareness and subjective sleep quality in night workers.

5. Effect of non-pharmacological on occupation types

Non-pharmacological interventions showed significantly positive effect on night workers in healthcare and industrial or manufacturing industries. Surprisingly, the pooled effect size was larger on the latter group of workers. Although it is difficult to determine exactly how the interventions are more effective in workers engaged in industrial or manufacturing industries, possible explanation may be related to the nature of work itself.

Healthcare workers often have highly stressful work environments that demand fast-paced decision making ability, flexible coping ability and adaptability to deal with emergency situations, terminally ill patients, grieving family members and more. Studies have shown that in healthcare workers, highly intense, stressful work environment exacerbates sleep disturbances, especially for reduced sleep length and sleep quality off-shift (Booker, Magee, Rajaratnam, Sletten, & Howard, 2018; Portela et al., 2015). Also, given that healthcare workers commonly face limited resources during the night hours compared to daytime to carry out tasks to restore patient's health, the work-related stress may be higher among night workers. Perhaps a singular interventional method may not be adequate in managing sleep disturbances in night workers engaged in healthcare which holds challenging nature.

A recent review that investigated individual characteristics associated with sleep disturbances in healthcare workers also suggested that the majority of workers being female may also contribute to vulnerability to sleep deprivation (Booker et al., 2018). A large percentage of healthcare workers are comprised of female population compared to other occupations that offer night work positions, which is most apparent in the nursing profession (Booker et al., 2018; M. Leung et al., 2016; Nena et al., 2018). In general, female workers are more likely than males to hold extended responsibilities outside of work including domestic duties with families, child raising and social commitments (Bergman, Ahmad, & Stewart, 2008; Clissold, Smith, & Acutt, 2001; Silva-Costa, Rotenberg, Griep, & Fischer, 2011). These additional non-work-related responsibilities further impact sleep length and quality off-shift, which disables adequate recovery from night work and, thus, increase sleepiness on-shift. Given that our selected studies also had a majority of female population representing the healthcare occupation, these factors may have resulted in muted effect.

6. Limitations

Our review had a few limitations that should be acknowledged. First, as identified studies incorporated diverse and complex non-pharmacological interventions and outcome measures, it may have contributed to a discrepancy in the diagnosis and severity of sleep disturbances. However, we attempted to pool data according to each interventional method and outcome measure to determine overall effect within each subgroup. Second, we were unable to investigate the effect of additional moderators such as gender, age group, socio-economic status and comorbidities due to insufficient data. Only few studies reported these aspects, which made it impossible to conduct moderator analysis. Third, the included studies generally had unclear to high risk of biases, especially in relation to performance and detection. Most of the studies raised concerns due to failure to report detailed description or only report blurred description of participant and observer blinding. Also, studies raised concerns due to a lack of controlling potential factors that may influence the effect estimates such as other sleep disturbance countermeasures (e.g. caffeine intake) or work conditions. This lack of standardization among studies may have contributed to variability and heterogeneity seen in the results.

7. Significance of research

Despite the several proposed limitations, this review updates and expands previous knowledge on non-pharmacological interventions in relieving sleep disturbances among night workforce. We conducted an extensive literature search by including multiple databases and journals, building search query with a broad range of search terms and not limiting searches by date or language to achieve high sensitivity.

Also, it is noteworthy that we have specified search terms and key terms for our population of interest as 'night workers.' In previous reviews, many researchers incorporated terms 'shift work' or 'shift workers' to indicate those who are involved in night work (Neil-Sztramko et al., 2014; Nena et al., 2018; Ruggiero & Redeker, 2014; Slanger et al., 2016). These terms may decrease specificity in answering the study question due to the term 'shift work' referring not only the night work positions but also varying day work positions such as morning shift, afternoon shift and evening shift (Akerstedt et al., 2008; Costa, 2003; International Labour Organization, 2004). Therefore, we are confident that we have achieved high sensitivity and specificity in the literature search process in answering our leading study questions.

We also limited our included studies to those that investigated workers in a real-world workplace settings and excluded study results observing participants in sleep laboratory settings with simulated night work environment. While the laboratory-based data plays an important role in understanding basic mechanisms underlying circadian misalignment and sleep physiology, significant effect size of interventions in such research may not translate well and may not be regenerated in the real-world setting (Neil-Sztramko et al., 2014; Slanger et al., 2016). Previous studies and reviews often combined results obtained from both real-world settings and laboratory-settings in answering our key questions (Nagashima et al., 2018; Pajcin et al., 2019; Pinto et al., 2011; Slanger et al., 2016). These studies were generally performed on healthy adults, which limits understanding the effects of chronic night work involvement on sleep and the feasibility of interventions. Some of the non-pharmacological strategies included in our review have shown to be significantly effective in improving sleep in healthy participants in a laboratory setting with controlled environmental and behavioral conditions (Pajcin et al., 2019; Slanger et al., 2016). These studies have suggested that less effect or a lack of effect is commonly observed in real-world setting due to inability to control varying aspects of the study and due to the complex nature involved with night work (Slanger et al., 2016). Therefore, our study results may be more generalizable and reflect true values of the real-world compared to previous results.

CHAPTER VII. CONCLUSIONS & RECOMMENDATIONS

Continuing growth in the workforce engaged in night work is expected due to increasing societal demands for around-the-clock services. The findings of this review suggest that non-pharmacological interventions hold a promising and beneficial improvement in sleep disturbances in night workers. Although no single ideal strategy is identified to successfully address all three major aspects of sleep risks among night workers, we suggest a combined non-pharmacological sleep disturbance prevention programs and policies that are customized to the specific employer and workers in successful prevention and management of night workers' sleep health. Nonetheless, the currently available literature is fairly small in quantity, holds heterogeneous nature, and lacked to fully explore potential modifying factors such as chronotypes, work contexts, work patterns and individual characteristics. Also, current trials have failed to include comprehensive descriptions of study methodology, which raised concerns for potential risk of bias. Further investigations to test effect of mixed interventions with careful consideration to possible modifiers in real-world workplace settings are suggested to enhance sleep health in night workers.

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APPENDIXES

Appendix 1 PRISMA 2009 checklist

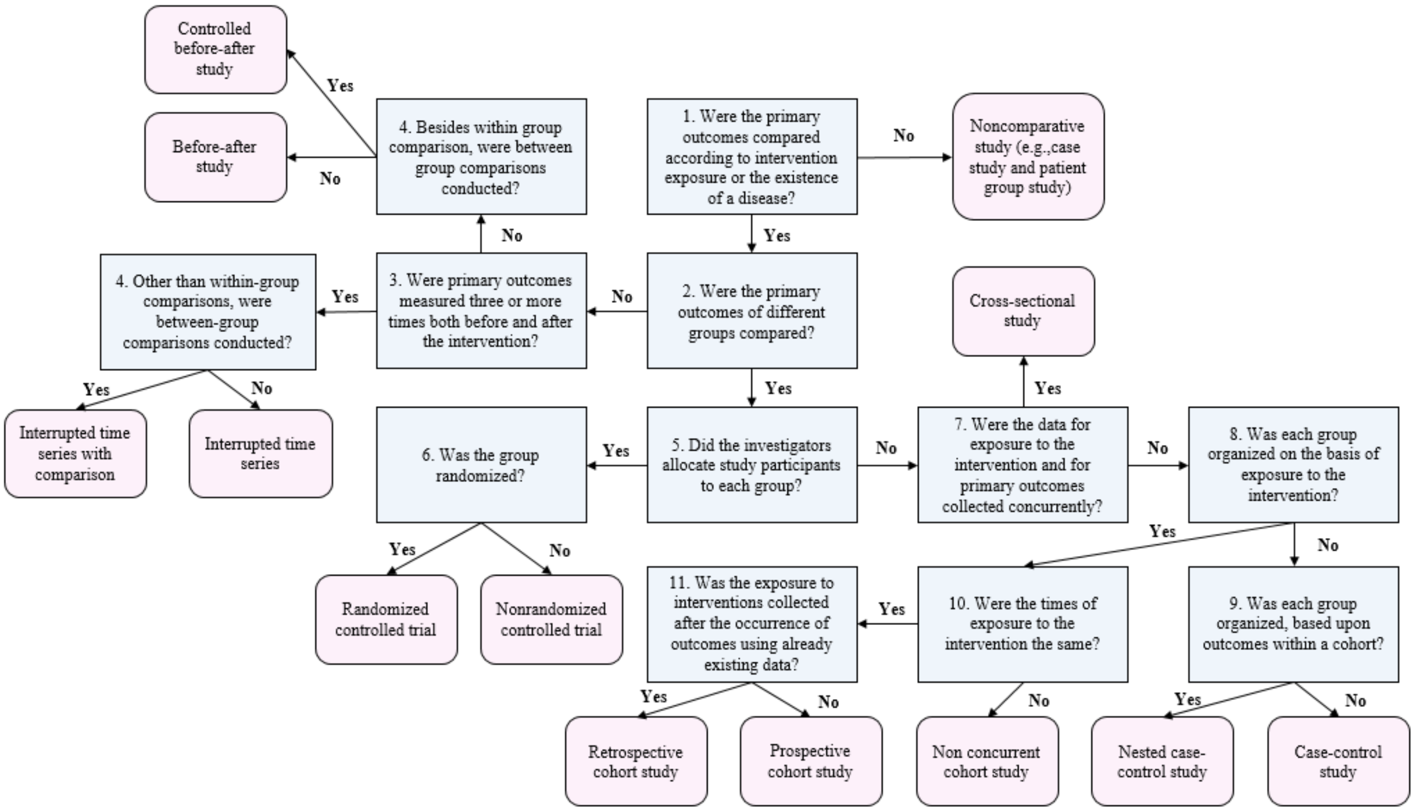
Section/topic	#	Checklist item	Page #
TITLE			
Title	1	Identify the report as a systematic review, meta-analysis, or both.	Title page
ABSTRACT			
Structured summary	2	Provide a structured summary including, as applicable: background; objectives; data sources; study eligibility criteria, participants, and interventions; study appraisal and synthesis methods; results; limitations; conclusions and implications of key findings; systematic review registration number.	Abstract page (i)
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of what is already known.	1-4 9-13
Objectives	4	Provide an explicit statement of questions being addressed with reference to participants, interventions, comparisons, outcomes, and study design (PICOS).	5
METHODS			
Protocol and registration	5	Indicate if a review protocol exists, if and where it can be accessed (e.g., Web address), and, if available, provide registration information including registration number.	24-25
Eligibility criteria	6	Specify study characteristics (e.g., PICOS, length of follow-up) and report characteristics (e.g., years considered, language, publication status) used as criteria for eligibility, giving rationale.	15-18
Information sources	7	Describe all information sources (e.g., databases with dates of coverage, contact with study authors to identify additional studies) in the search and date last searched.	19-21
Search	8	Present full electronic search strategy for at least one database, including any limits used, such that it could be repeated.	19-20 Appendix 5

Study selection	9	State the process for selecting studies (i.e., screening, eligibility, included in systematic review, and, if applicable, included in the meta-analysis).	21-22 26-27
Data collection process	10	Describe method of data extraction from reports (e.g., piloted forms, independently, in duplicate) and any processes for obtaining and confirming data from investigators.	21-22 Appendix 4
Data items	11	List and define all variables for which data were sought (e.g., PICOS, funding sources) and any assumptions and simplifications made.	Appendix 6
Risk of bias in individual studies	12	Describe methods used for assessing risk of bias of individual studies (including specification of whether this was done at the study or outcome level), and how this information is to be used in any data synthesis.	23
Summary measures	13	State the principal summary measures (e.g., risk ratio, difference in means).	24-28
Synthesis of results	14	Describe the methods of handling data and combining results of studies, if done, including measures of consistency (e.g., I^2) for each meta-analysis.	24-28
Risk of bias across studies	15	Specify any assessment of risk of bias that may affect the cumulative evidence (e.g., publication bias, selective reporting within studies).	21-24
Additional analyses	16	Describe methods of additional analyses (e.g., sensitivity or subgroup analyses, meta-regression), if done, indicating which were pre-specified.	24-28 Appendix 10
RESULTS			
Study selection	17	Give numbers of studies screened, assessed for eligibility, and included in the review, with reasons for exclusions at each stage, ideally with a flow diagram.	30-31
Study characteristics	18	For each study, present characteristics for which data were extracted (e.g., study size, PICOS, follow-up period) and provide the citations.	32-39 Table 7, Appendix 6
Risk of bias within studies	19	Present data on risk of bias of each study and, if available, any outcome level assessment (see item 12).	45 Figure 4, Appendix 6
Results of individual	20	For all outcomes considered (benefits or harms), present, for each study: (a) simple summary data for each intervention group (b) effect estimates and confidence intervals,	47-65

studies		ideally with a forest plot.	Table 5, Table 8 Figure 5~10 Appendix 6~7
Synthesis of results	21	Present results of each meta-analysis done, including confidence intervals and measures of consistency.	47-65 Table 5, Table 8, Figure 5 ~ 10
Risk of bias across studies	22	Present results of any assessment of risk of bias across studies (see Item 15).	45 Figure 3
Additional analysis	23	Give results of additional analyses, if done (e.g., sensitivity or subgroup analyses, meta-regression [see Item 16]).	50-68 Figure 5 ~ 10
DISCUSSION			
Summary of evidence	24	Summarize the main findings including the strength of evidence for each main outcome; consider their relevance to key groups (e.g., healthcare providers, users, and policy makers).	69-75
Limitations	25	Discuss limitations at study and outcome level (e.g., risk of bias), and at review-level (e.g., incomplete retrieval of identified research, reporting bias).	75
Conclusions	26	Provide a general interpretation of the results in the context of other evidence, and implications for future research.	77
FUNDING			
Funding	27	Describe sources of funding for the systematic review and other support (e.g., supply of data); role of funders for the systematic review.	27

From: Moher D, Liberati A, Tetzlaff J, Altman DG, The PRISMA Group (2009). Preferred Reporting Items for Systematic Reviews and Meta-Analyses: The PRISMA Statement. PLoS Med 6(7): e1000097. doi:10.1371/journal.pmed1000097

Appendix 2 The DAMI in defining study design



Appendix 3 Certification of approval for the request for exemption

SNUIRB-2019-NH-002

인간대상연구 여부 확인서

수신	연구책임자	성명	박다인	소속	간호학과	직위	박사과정
	지원기관						
연구과제명	야간 근무자의 수면 장애에 대한 비약물적 중재의 효과 : 체계적 문헌고찰 및 메타분석						
사유	본 연구는 연구참여자의 개인별 data는 사용하지 않고 기 출판된 논문 내용을 분석하는 연구임.						
확인일자	2019 년 5 월 17 일						

상기 연구과제에 대하여 인간대상연구 여부를 검토한 결과
「생명윤리 및 안전에 관한 법률」 제2조 및 동법 시행규칙 제2조에 근거하여
인간대상연구가 아님을 확인합니다.

2019년 5월 17일

서울대학교 생명윤리위원회 위원장

Appendix 4 A checklist for developing a search strategy

#	Search strategy steps	V
1	Define text words	V
2	Identify “controlled vocabulary” (keywords) used for the indexing of databases (MeSH for MEDLINE, EMTREE for EMBASE, CINAHL headings for CINAHL)	V
3	Decide on whether to perform an “exploded” or a “focused” search for keywords	V
4	Check if all words are spelled correctly	V
5	Customize the syntax of search strategy specific to database by logically combining search terms	V
6	Perform test searches	V

1. Define text words

Component	Text word	Definition
Population	Night shift	[Dictionary] The work force, as of a factory, scheduled to work during the nighttime; the scheduled period of labor for this work force [Mesh] N/A [EMTREE] Night shiftwork; night work; nightshift; nightwork; overnight shift; overnight work [CINAHL heading]
	Graveyard shift	[Dictionary] A work shift usually beginning at about midnight and continuing for about eight hours through the early morning hours; those who work this shift [Mesh] N/A [EMTREE] N/A [CINAHL heading] N/A
	Shift work	[Dictionary] A system of employment where an individual’s normal hours of work are, in part, outside the period of normal day working and may follow a different pattern in consecutive periods of weeks [MeSH] N/A [EMTREE] N/A [CINAHL heading]

		A nonstandard work shift, including evening or night shifts.
	Shift work schedule	[Dictionary] N/A [MeSH] Job schedule in which working hours deviate from the standard hours (e.g., evening shift, night shift or rotating shift) [EMTREE] N/A [CINAHL heading] N/A
Outcomes	Sleep	[Dictionary] To take the rest afforded by a suspension of voluntary bodily functions and the natural suspension, complete or partial, of consciousness; cease being awake [MeSH] A readily reversible suspension of sensorimotor interaction with the environment, usually associated with recumbency and immortality [EMTREE] A period of rest for the body and mind, during which volition and consciousness are in partial or complete abeyance and the bodily functions partially suspended. Sleep has also been described as a behavioral state marked by a characteristic immobile posture and diminished but readily reversible sensitivity to external stimuli. Sleep is divisible into two types: NREM (non–rapid eye movement) s. and REM (rapid eye movement) s. [CINAHL heading] N/A
	Sleep disturbance	[Dictionary] N/A [MeSH] N/A [EMTREE] N/A [CINAHL heading] Disruption of sleep time causing discomfort or interference with desired life activities. Use only as a specific North American Nursing Diagnosis Association nursing diagnosis.
	Sleep wake disorders	[Dictionary] N/A [MeSH] Abnormal sleep-wake schedule or pattern associated with circadian rhythm which affect the length, timing, and/or rigidity of the sleep-wake cycle relative to the day-night cycle [EMTREE] N/A [CINAHL heading]

	N/A
Insomnia	[Dictionary] Inability to obtain sufficient sleep, especially when chronic; difficulty in falling or staying asleep; sleeplessness [MeSH] N/A [EMTREE] Inability to sleep; abnormal wakefulness. [CINAHL heading] Impairment of the ability to enter into or to maintain sleep.
Sleep initiation and maintenance disorder	[Dictionary] N/A [MeSH] Disorders characterized by impairment of the ability to initiate or maintain sleep. This may occur as a primary disorder or in association with another medical or psychiatric condition. [EMTREE] N/A [CINAHL heading] N/A
Dyssomnia	[Dictionary] A disturbance in the normal rhythm or pattern of sleep [MeSH] A broad category of sleep disorders characterized by either hypersomnolence or insomnia. The three major subcategories include intrinsic (i.e., arising from within the body) (SLEEP DISORDERS, INTRINSIC), extrinsic (secondary to environmental conditions or various pathologic conditions), and disturbances of circadian rhythm. [EMTREE] N/A [CINAHL heading] Sleep disorders characterized by difficulty falling or staying asleep.
Circadian rhythm disorder	[Dictionary] N/A [MeSH] Disruptions of the rhythmic cycle of bodily functions or activities; Chronobiological disorder [EMTREE] Sleep disorder of the dyssomnia group, consisting of a lack of synchrony between the schedule of sleeping and waking required by the external environment and that of a person's own circadian rhythm. It usually has an environmental cause such

	as rotating shift work or long-distance air travel, although some individuals simply have natural circadian rhythms sharply different from the predominant one of their society. [CINAHL heading] Disturbances of the normal sleep-wake cycle due to travel or shift work.

2. Identify “controlled vocabulary” (keywords) used for the indexing of databases (MeSH for MEDLINE, EMTREE for EMBASE, CINAHL headings for CINAHL)
3. Decide on whether to perform an “exploded” or a “focused” search for keywords
4. Check if all words are spelled correctly

P + O	Text word	MeSH entry terms	EMTREE synonyms	CINAHL synonyms
P	Night shift Night work Shift Work Shift Work Schedule	[MeSH term] SHIFT WORK SCHEDULE Schedule, Shift Work Schedules, Shift Work Work Schedule, Shift Night Shift Work Shift Work, Night Rotating Shift Work Shift Work, Rotating	[EMTREE TERM] NIGHT SHIFT; NIGHT SHIFT WORKER Night shiftwork Night work Nightshift Nightwork Overnight shift Overnight work	[CINAHL HEADING] SHIFT WORK Shiftwork Shift workers Night workers Night shift
O	Sleep	[MeSH term] SLEEP ~~Dreams~~ Sleep deprivation Sleep hygiene Sleep latency Sleep stages Sleep, REM Sleep, Slow-wave	[EMTREE TERM] SLEEP Activated sleep REM sleep	[CINAHL HEADING] SLEEP ~~Dreams~~ Sleep deprivation Sleep hygiene Sleep latency Sleep stages
	Sleep disturbance	[MeSH term] SLEEP WAE DISORDERS Sleep deprivation Sleep disorders, circadian rhythml	[EMTREE TERM] SLEEP DISORDER ~~Abnormal dreaming~~	[CINAHL HEADING] SLEEP PATTERN DISTURBANCE

	Sleep disorders, intrinsic Parasomnia Nocturnal myoclonus syndrome Nocturnal paroxysmal dystonia Restless legs syndrome Sleep bruxism Sleep-wake transition disorders	~~Benign neonatal sleep myoclonus~~ Circadian rhythm sleep disorder Daytime somnolence Drowsiness Excessive dreaming ~~Exploding head syndrome~~ Fragmented sleep Hypersomnia Insomnia Jet lag ~~Narcolepsy~~ ~~Nightmare~~ Parasomnia ~~Paroniria~~ Periodic limb movement disorder Sleep debt Sleep arousal disorder ~~Sleep walking somnolence~~ ~~Unpleasant dream~~ ~~Vivid dream~~	~~Activity intolerance~~ ~~Activity intolerance risk~~ ~~Diversional activity deficit~~ Fatigue ~~Physical mobility impairment~~ Sleep deprivation
Sleep wake disorders	[MeSH term] SLEEP WAKE DISORDER Disorder, sleep wake Disorders, sleep wake Subwakefulness syndrome	[EMTREE TERM] SAME AS SLEEP DISORDER	[CINAHL HEADING] SLEEP DISORDERS, CIRCADIAN RHYTHM Jat lag syndrome
Insomnia	[MeSH term] N/A	[EMTREE TERM] INSOMNIA ~~Fatal familial insomnia~~ Primary insomnia	[CINAHL HEADING] INSOMNIA ~~Fatal familial insomnia~~ Restless legs Sleep apnea syndromes
Sleep initiation and maintenance disorder	[MeSH term] SLEEP INITIATION AND MAINTENANCE DISORDER DIMS (Disorders of Initiating and Maintaining sleep	[EMTREE TERM] N/A	[CINAHL HEADING] N/A

	Awakening, early insomnia Insomnia, nonorganic Rebound insomnia		
Dyssomnia	[MeSH term] DYSSOMNIAS Sleep disorders, extrinsic Extrinsic sleep disorder Limit-setting sleep disorder Nocturnal eating-drinking syndrome Adjustment sleep disorder Environmental sleep disorder	[EMTREE TERM] SAME AS SLEEP DISORDER	[CINAHL HEADING] DYSSOMNIAS Sleep deprivation
Circadian rhythm disorder	[MeSH term] SLEEP DISORDERS, CIRCADIAN RHYTHM Disturbed nyctohemeral rhythms Circadian rhythm sleep disorders Non-24 hour sleep-wake disorder Advanced sleep wake cycle disorder Delayed sleep phase syndrome	[EMTREE TERM] CIRCADIAN RHYTHM SLEEP DISODERS Sleep disorders, circadian rhythm	[CINAHL HEADING] SLEEP DISORDERS, CIRCADIAN RHYTHM Disturbed nyctohemeral rhythm Chronobiology disorders Jet lag syndrome ~~Smith-Magenis syndrome~~

5. Customize the syntax of search strategy specific to database by logically combining search terms

6. Perform test searches

1) DB: MEDLINE (Ovid)

PICOTS-SD	#	Search history	Results
P	1	Occupational Diseases[mh] OR Occupational Health[mh] OR Occupational Injuries[mh] OR Occupations[mh] OR Personnel Management[mh] OR Personnel Staffing and Scheduling[mh] OR Time Factors[mh] OR Work Schedule Tolerance[mh] OR Workload[mh] OR Work[mh] OR shift*[tiab] OR shift*[ot] OR shiftwork[tiab] OR shiftwork[ot]	1,811,027
	2	"Schedule, Shift Work"[Mesh] OR "Schedules, Shift Work"[Mesh] OR "Work Schedule, Shift"[Mesh] OR "Night Shift Work"[Mesh] OR "Shift Work, Night" OR “Rotating Shift Work"[Mesh] OR "Work Schedule Tolerance"[Mesh]	6,559
	3	(shift [TiAb] AND work) OR (night [TiAb] AND shift) OR (night [TiAb] AND work) OR shift work [Title/Abstract] OR night shift* [TiAb] OR work* [TiAb])	1,389,895
	4	(((shift OR shifts) adj1 (rota OR system OR systems OR schedul* OR hours OR time OR pattern$ OR cycle OR extend$ OR late OR twilight OR graveyard OR night$ OR split OR non-standard OR flex$ OR turnaround OR continuous OR rotat$)))	1
	5	(rota OR roster OR ’day week’ OR flexitime OR ’hours of work’ OR nightshift* OR shiftwork*)	5,882
	6	((work$ OR duty) adj1 (shift OR shifts OR rota OR system OR systems OR schedul* OR hours OR time OR pattern$ OR cycle OR extend$ OR evening OR late OR roster OR early OR weekend OR twilight OR graveyard OR night* OR split OR non-standard OR “non standard” OR flex$ OR turnaround OR continuous OR rotation$))	5
	7	((backward OR forward OR rapid OR slow OR rapidly OR slowly OR advancing OR delaying) adj1 (rotation OR rotate OR rotating))	32
	8	(rota OR roster OR duty OR shift OR shifts OR shiftwork OR hours OR week OR work).mp.	2,484
	9	1 OR 2 OR 3 OR 4 OR 5 OR 6 OR 7 OR 8	3,004,414
O	10	Sleep[mh] OR sleep[tiab] OR sleep[ot]	170,780
	11	sleep quality[tiab] OR sleep quality[ot] OR quality of sleep[tiab] OR quality of sleep[ot] OR sleep inertia[tiab] OR sleep inertia[ot] OR sleep latency[tiab] OR sleep latency[ot] OR sleep homeostasis[tiab] OR sleep homeostasis[ot] OR sleep health[tiab] OR sleep health[ot] OR sleep hygiene[tiab] OR sleep hygiene[ot] OR sleep-wake cycle[tiab] OR sleep-wake cycle[ot] OR sleep pressure[tiab] OR sleep pressure[ot]	20,489

	12	Sleep Stages[mh] OR sleep stage*[tiab] OR sleep stage*[ot] OR sleep phase*[tiab] OR sleep phase*[ot] OR drowsiness[tiab] OR drowsiness[ot] OR sleepiness[tiab] OR sleepiness[ot] OR nap[tiab] OR nap[ot] OR naps[tiab] OR Relaxation[mh] OR Rest[mh]	63,977
	13	Sleep, REM[mh] OR REM Sleep[tiab] OR REM Sleep[ot] OR Rhombencephalic Sleep[tiab] OR Rhombencephalic Sleep[ot] OR Fast-Wave Sleep[tiab] OR Fast-Wave Sleep[ot] OR Fast Wave Sleep[tiab] OR Fast Wave Sleep[ot] OR Paradoxical Sleep[tiab] OR Paradoxical Sleep[ot] OR Fast-Wave Sleep[tiab] OR Fast-Wave Sleep[ot]	18,406
	14	Melatonin[mh] OR Chronobiology Phenomena[mh] OR Biological Clocks[mh] OR Light[mh] OR Lighting[mh] OR Circadian Rhythm[mh] OR Melatonin[tiab] OR Chronobiolog*[tiab] OR Chronobiolog*[ot] OR Biological Clock*[tiab] OR Biological Clock*[ot] OR Biologic Clock*[tiab] OR Biologic Clock*[ot] OR Biologic* Oscillator*[tiab] OR Biologic* Oscillator*[ot] OR Biologic* Pacemaker*[tiab] OR Biologic* Pacemaker*[ot] OR Endogenous Oscillator*[tiab] OR Endogenous Oscillator*[ot] OR Circadian Rhythm*[tiab] OR Circadian Rhythm*[ot] OR Twenty-Four Hour Rhythm*[tiab] OR Twenty-Four Hour Rhythm*[ot] OR Twenty Four Hour Rhythm*[tiab] OR Twenty Four Hour Rhythm*[ot] OR Ultradian Rhythm*[tiab] OR Ultradian Rhythm*[ot] OR Diurnal Rhythm*[tiab] OR Diurnal Rhythm*[ot] OR Nyctohemeral Rhythm*[tiab] OR Nyctohemeral Rhythm*[ot] OR 24-hour rhythm*[tiab] OR 24-hour rhythm*[ot]	29,408
	15	Wakefulness[mh] OR Arousal[mh] OR Attention[mh] OR Wakefulness[tiab] OR Wakefulness[ot] OR arousal[tiab] OR arousal[ot] OR alertness[tiab] OR alertness[ot] OR vigilance[tiab] OR vigilance[ot] OR attention[tiab] OR attention[ot]	478,766
	16	Sleep Deprivation[mh] OR sleep deprivation*[tiab] OR sleep deprivation*[ot] OR sleep fragmentation*[tiab] OR sleep fragmentation*[ot] OR insufficient sleep syndrome*[tiab] OR insufficient sleep syndrome*[ot]	12,876
	17	Sleep Disorders, Circadian Rhythm[mh] OR Disturbed Nyctohemeral Rhythm*[tiab] OR Disturbed Nyctohemeral Rhythm*[ot] OR Circadian Rhythm Sleep Disorder*[tiab] OR Circadian Rhythm Sleep Disorder*[ot] OR Sleep-Wake Cycle Disorder*[tiab] OR Sleep-Wake Cycle Disorder*[ot] OR Sleep Wake Cycle Disorder*[tiab] OR Sleep Wake Cycle Disorder*[ot] OR Sleep-Wake Schedule Disorder*[tiab] OR Sleep-Wake Schedule Disorder*[ot] OR Sleep Wake Schedule Disorder*[tiab] OR Sleep Wake Schedule Disorder*[ot] OR Shift-Work	2,561

		Sleep Disorder*[tiab] OR Shift-Work Sleep Disorder*[ot] OR Shift Work Sleep Disorder*[tiab] OR Shift Work Sleep Disorder*[ot] OR Non-24 Hour Sleep-Wake Disorder*[tiab] OR Non-24 Hour Sleep-Wake Disorder*[ot] OR Non 24 Hour Sleep Wake Disorder*[tiab] OR Non 24 Hour Sleep Wake Disorder*[ot] OR Non Twenty-Four Hour Sleep-Wake Disorder*[tiab] OR Non Twenty-Four Hour Sleep-Wake Disorder*[ot] OR Non Twenty-Four Hour Sleep Wake Disorder*[tiab] OR Non Twenty-Four Hour Sleep Wake Disorder*[ot] OR Nonorganic Sleep Wake Cycle Disorder*[tiab] OR Nonorganic Sleep Wake Cycle Disorder*[ot] OR Advanced Sleep Phase Syndrome*[tiab] OR Advanced Sleep Phase Syndrome*[ot] OR Delayed Sleep Phase Syndrome*[tiab] OR Delayed Sleep Phase Syndrome*[ot] OR Delayed Sleep-Phase Syndrome*[tiab] OR Delayed Sleep-Phase Syndrome*[ot]	
	18	Disorders of Excessive Somnolence[mh] OR Disorders of Excessive Somnolence[tiab] OR Disorders of Excessive Somnolence[ot] OR Excessive Somnolence Disorder*[tiab] OR Excessive Somnolence Disorder*[ot] OR Hypersomnolence[tiab] OR Hypersomnolence[ot]Hypersomnia*[tiab] OR Hypersomnia*[ot]	1,042
	19	Sleep Wake Disorders[mh] OR Sleep Wake Disorder*[tiab] OR Sleep Wake Disorder*[ot] OR Subwakefulness Syndrome*[tiab] OR Subwakefulness Syndrome*[ot] OR Sleep Disorder*[tiab] OR Sleep Disorder*[ot] OR Sleep Disorder*[tiab] OR Sleep Disorder*[ot] OR Sleep Related Neurogenic Tachypnea*[tiab] OR Sleep Related Neurogenic Tachypnea*[ot] OR Sleep-Related Neurogenic Tachypnea*[tiab] OR Sleep-Related Neurogenic Tachypnea*[ot] OR Long Sleeper Syndrome*[tiab] OR Long Sleeper Syndrome*[ot] OR Short Sleeper Syndrome*[tiab] OR Short Sleeper Syndrome*[ot] OR Short Sleep Phenotype*[tiab] OR Short Sleep Phenotype*[ot]	88,733
	20	Sleep Initiation and Maintenance Disorders[mh] OR Disorders of Initiating and Maintaining Sleep*[tiab] OR Disorders of Initiating and Maintaining Sleep*[ot] OR DIMS[tiab] OR DIMS[ot] OR Early Awakening*[tiab] OR Early Awakening*[ot] OR Insomnia*[tiab] OR Insomnia*[ot] OR Sleep Initiation Dysfunction*[tiab] OR Sleep Initiation Dysfunction*[ot] OR Sleeplessness*[tiab] OR Sleeplessness*[ot]	24,033
	21	Sleep Arousal Disorders[mh] OR Sleep Arousal Disorder*[tiab] OR Sleep Arousal Disorder*[ot] OR Confusional Arousals*[tiab] OR Confusional Arousals*[ot]	907

	22	Sleep Disorders, Intrinsic[mh] OR Intrinsic Sleep Disorder*[tiab] OR Intrinsic Sleep Disorder*[ot] OR Sleep State Misperception*[tiab] OR Sleep State Misperception*[ot] OR Post-Traumatic Hypersomnia*[tiab] OR Post-Traumatic Hypersomnia*[ot] OR Posttraumatic Hypersomnia*[tiab] OR Posttraumatic Hypersomnia*[ot]	52,892
	23	Dyssomnias[mh] OR Dyssomnia*[tiab] OR Dyssomnia*[ot] OR Environmental Sleep Disorder*[tiab] OR Environmental Sleep Disorder*[ot] OR Extrinsic Sleep Disorder*[tiab] OR Extrinsic Sleep Disorder*[ot] OR Limit-Setting Sleep Disorder*[tiab] OR Limit-Setting Sleep Disorder*[ot] OR Limit Setting Sleep Disorder*[tiab] OR Limit Setting Sleep Disorder*[ot] OR Nocturnal Eating-Drinking Syndrome*[tiab] OR Nocturnal Eating-Drinking Syndrome*[ot] OR Nocturnal Eating Drinking Syndrome*[tiab] OR Nocturnal Eating Drinking Syndrome*[ot] OR Adjustment Sleep Disorder*[tiab] OR Adjustment Sleep Disorder*[ot] OR Inadequate Sleep Hygiene*[tiab] OR Inadequate Sleep Hygiene*[ot]	63,307
	24	10 OR 11 OR 12 OR 13 OR 14 OR 15 OR 16 OR 17 OR 18 OR 19 OR 20 OR 21 OR 22 OR 23	687,875
SD	25	Randomized controlled trial. pt	7,067
	26	Controlled clinical trial. pt	8,407
	27	Randomized. tiab	8
	28	Placebo. tiab	21
	29	Clinical trials as topic. mesh: noexp	11
	30	Randomly. tiab	8
	31	Trial. ti	1,029
	32	(effect* OR controll* OR control OR controls* OR controli* OR controle* OR controla* OR evaluation* OR program*).tw.	45,173
	33	((randomized controlled trial OR controlled clinical trial).pt. OR randomized.ab. OR placebo.ab. OR randomly. ab. OR trial.ab. OR groups.ab.)	13,371
	34	evaluation studies/ OR feasibility studies/ OR longitudinal studies/ OR program evaluation/ OR prospective studies/ OR retrospective studies/ OR exp follow-up studies/ OR exp risk Factors/ OR exp evaluation studies/ OR exp retrospective Studies OR exp chi-square distribution/ OR logistic models/ OR exp treatment outcome/ OR exp comparative studies	2,784,650
	35	25 OR 26 OR 27 OR 28 29 OR 30 OR 31 Or 32 OR 33 OR 34	2,831,620
P + O + SD	36	9 AND 24 AND 35	16,521
Limit	37	exp ANIMALS	262,223
	38	HUMANS/	17,845,733

	39	45 NOT 46	206,175
Final	40	36 NOT 39 39	16,432

2) DB: EMBASE (Embase.com)

PICOTS-SD	**#**	**Search history**	**Results**
P	1	((work NEAR/2 hour*) OR (shift NEAR/2 work*) OR (work* NEAR/2 week) OR nightshift* OR shiftwork* OR (day NEAR/2 schedule))	20,188
	2	((rotat* NEAR/2 (backward OR forward OR rapid OR slow OR rapidly OR slowly OR advancing OR delaying)) AND (shift* OR work* OR schedule OR time OR duty OR hours OR rota OR roster))	916
	3	(shift$ NEAR/1 (rota OR system$ OR schedul* OR hours OR time OR pattern* OR cycle OR extend* OR evening OR late OR roster OR early OR weekend OR twilight OR graveyard OR night$ OR split OR non-standard OR "non standard" OR flex$ OR turnaround OR continuous OR rotat*))	9,553
	4	(shift* NEAR/2 (backward OR forward OR rapid OR slow OR rapidly OR slowly OR advancing OR delaying OR roster OR rota OR "day week"))	3,025
	5	1 OR 2 OR 3 OR 4	29,187
O	6	'sleep disorder' OR 'sleep disturbance scale' OR 'sleep disruption'	67,930
	7	(sleep NEAR/2 disturb*) OR sleep* OR (sleep AND disord*) OR (sleep AND disturb*) OR 'circadian rhythm' OR (circadian AND disrupt*) OR (circadian AND misalign*) OR (reverse AND circadian)	395,819
	8	sleep AND wake AND disord* OR (short AND sleep*) OR (long AND sleep*) OR (shiftwork AND disorder) OR (shift* AND work* AND disord*)	63,141
	9	6 OR 7 OR 8	399,584
P + O	10	5 AND 9	8,142
SD†	11	random*:ab,ti OR (clinical NEXT/1 trial*):de,ab,ti OR 'health care quality'/exp	4,860,792
	12	(double NEXT/1 blind*):de,ab,ti OR placebo*:ab,ti OR blind*:ab,ti	566,782
	13	random*:ab,ti OR placebo*:de,ab,ti OR (double NEXT/1 blind*):ab,ti	1,655,323
	14	'crossover procedure':de OR 'double-blind procedure':de OR 'randomized controlled trial':de OR 'single-blind procedure':de OR (random* OR factorial* OR crossover* OR cross NEXT/1 over*	2,400,849

† EMBASE syntax customized based on the following reference: Wong SS, Wilczynski NL, Haynes RB. (2006). Developing optimal search strategies for detecting clinically sound treatment studies in EMBASE. *Journal of the Medical Library Association: JMLA*, 94(1), 41-7.

		OR placebo* OR doubl* NEAR/1 blind* OR singl* NEAR/1 blind* OR assign* OR allocat* OR volunteer*):de,ab,ti	
	15	'clinical trial'/de OR 'randomized controlled trial'/de OR 'randomization'/de OR 'single blind procedure'/de OR 'double blind procedure'/de OR 'crossover procedure'/de OR 'placebo'/de OR 'prospective study'/de OR 'randomi?ed controlled' NEXT/1 trial* OR rct OR 'randomly allocated' OR 'allocated randomly' OR 'random allocation' OR allocated NEAR/2 random OR single NEXT/1 blind* OR double NEXT/1 blind* OR (treble OR triple) NEAR/1 blind* OR placebo*	2,139,390
	16	10 OR 11 OR 12 OR 13 OR 14 OR 15	5,900,701
Final	37	10 AND 16	2,153

3) DB: CINAHL Plus with Full Text (EBSCO)

PICOTS-SD	#	Search history	Results
P	1	(MH "Shift work") OR (MH "Night work") OR (MH "Rotating shift work") OR (MH “Graveyard shift”) OR (MH "Occupations and Professions") OR (MH "Personnel Management") OR (MH "Personnel Staffing and Scheduling") OR (MH "Shift Workers") OR "shift*" OR (MH "Shiftwork") OR "shiftwork" OR "shift work" OR (MH "Stress, Occupational") OR (MH "Time Factors") OR (MH "Work") OR "work schedule*" OR (MH "Workload") OR "workload" OR (MH "Work Environment")	118,982
	2	(MH "Occupational Diseases") OR (MH "Occupational Health") OR (MH "Occupational-Related Injuries") OR (MH "Occupations and Professions") OR (MH "Personnel Management") OR (MH "Personnel Staffing and Scheduling") OR (MH "Shift Workers") OR "shift*" OR (MH "Shiftwork") OR "shiftwork" OR "shift work" OR (MH "Stress, Occupational") OR (MH "Time Factors") OR (MH "Work") OR "work schedule*" OR (MH "Workload") OR "workload" OR (MH "Work Environment")	127,141
	3	1 OR 2	127,141
O	4	(MH "Sleep") OR "sleep"	21,669
	5	"sleep quality" OR "quality of sleep" OR "sleep inertia" OR "sleep latency" OR "sleep homeostasis" OR "sleep health" OR "sleep hygiene" OR "sleep-wake cycle" OR "sleep pressure" OR "sleep time"	3,403
	6	(MH "Sleep Stages") OR "sleep stage*" OR "sleep phase*" OR "drowsiness" OR "sleepiness" OR (MH "Relaxation") OR (MH "Rejuvenation")	4,011

	7	(MH "Sleep, REM") OR "rem sleep" OR "rhombencephalic sleep" OR "fast-wave sleep" OR "fast wave sleep" OR "paradoxical sleep"	509
	8	(MH "Melatonin") OR (MH "Chronobiology Disorders") OR (MH "Biological Clocks") OR (MH "Light") OR (MH "Lighting") OR (MH "Circadian Rhythm") OR "melatonin" OR "chronobiolog*" OR "biological clock*" OR "biologic clock*" OR "biologic* oscillator*" OR "biologic* pacemaker*" OR "endogenous oscillator*" OR "circadian rhythm*" OR "twenty-four hour rhythm*" OR "twenty four hour rhythm*" OR "ultradian rhythm*" OR "diurnal rhythm*" OR "nyctohemeral rhythm*" OR "24-hour rhythm*"	5,894
	9	(MH "Chronotherapy") OR "sleep phase chronotherap*" OR "phase advance chronotherap*" OR "phase delay chronotherap*"	62
	10	(MH "Wakefulness") OR (MH "Arousal") OR (MH "Attention") OR "wakefulness" OR "arousal" OR "alertness" OR "vigilance"	12,374
	11	(MH "Sleep Deprivation") OR "sleep deprivation*" OR "sleep fragmentation*" OR "insufficient sleep syndrome*"	1,521
	12	(MH "Sleep Disorders, Circadian Rhythm") OR (MH "Sleep-Wake Transition Disorders") OR "disturbed nyctohemeral rhythm*" OR "circadian rhythm sleep disorder*" OR "sleep wake cycle disorder*" OR "sleep-wake schedule disorder*" OR "sleep wake schedule disorder*" OR "shift-work sleep disorder*" OR "shift work sleep disorder*" OR "non-24 hour sleep-wake disorder*" OR "non 24 hour sleep wake disorder*" OR "non twenty-four hour sleep-wake disorder*" OR "nonorganic sleep wake cycle disorder*" OR "advanced sleep phase syndrome*" OR "delayed sleep phase syndrome*" OR "delayed sleep-phase syndrome*"	188
	13	(MH "Disorders of Excessive Somnolence") OR (MH "Sleep Disorders$") OR "excessive somnolence disorder*" OR "hypersomnolence" OR "hypersomnia" OR "sleep wake disorder*" OR "subwakefulness syndrome*" OR "sleep disorder*" OR "sleep related neurogenic tachypnea" OR "sleep-related neurogenic tachypnea" OR "long sleeper syndrome" OR "short sleeper syndrome" OR "short sleep phenotype"	5,543
	14	(MH "Insomnia") OR "sleep initiation and maintenance disorders" OR "disorders of initiating and maintaining sleep" OR "dims" OR "early awakening" OR "insomnia*" OR "sleep initiation dysfunction" OR "sleeplessness"	3,646
	15	(MH "Sleep Arousal Disorders") OR "sleep arousal disorder" OR "confusional arousal*"	18

	16	(MH "Sleep Disorders, Intrinsic") OR "intrinsic sleep disorder*" OR "sleep state misperception*" OR "post-traumatic hypersomnia" OR "posttraumatic hypersomnia"	35
	17	(MH "Dyssomnias") OR "dyssomnia*" OR "environmental sleep disorder*" OR "extrinsic sleep disorder*" OR "limit-setting sleep disorder*" OR "limit setting sleep disorder*" OR "nocturnal eating-drinking syndrome*" OR "nocturnal eating drinking syndrome*" OR "adjustment sleep disorder*" OR "inadequate sleep hygiene"	76
	18	4 OR 6 OR 7 OR 8 OR 9 OR 10 OR 11 OR 12 OR 13 OR 14 OR 15 OR 16 OR 17	49,650
Final	19	3 and 18	1,362

4) DB: PsycINFO (EBSCO)

PICOTS-SD	**#**	**Search history**	**Results**
P	1	Occupational Diseases.mp. OR Occupational Health.mp. OR Occupational Health/ OR Occupational Injuries.mp. OR Work Related Illnesses/ OR occupational accident.mp. OR occupational hazard.mp. OR Occupations.mp. OR Occupations/ OR Personnel Management.mp. OR staffing.mp. OR scheduling.mp. OR Work Scheduling/ OR Workday Shifts/ OR shift work.mp. OR shift$.mp. OR shiftwork.mp. OR shift worker.mp. OR Time/ OR Time Factors.mp. OR temporal trends.mp. OR Work.mp. OR Work Load/ OR Workload.mp. OR Work Schedule Tolerance.mp. OR work environment.mp. OR work schedule.mp. OR working time.mp. OR Working Conditions/	838,405
	2	Night work.mp. OR Night shift.mp. OR Night shift work.mp. OR Graveyard shift.mp.	3,600
	3	1 OR 2	839,667
O	4	Sleep/ OR sleep.mp.	76,419
	5	sleep adj2 quality.mp. OR sleep inertia.mp. OR sleep latency.mp. OR sleep homeostasis.mp. OR sleep health.mp. OR sleep hygiene.mp. OR Sleep Wake Cycle/ OR sleep wake cycle$.mp. OR sleep-wake cycle$.mp. OR sleep pressure.mp. OR sleep time.mp.	5,300
	6	sleep stage$.mp. OR sleep phase$.mp. OR drowsiness.mp. OR Sleepiness/ OR sleepiness.mp.	8,060
	7	REM Sleep/ OR NREM Sleep/ OR REM sleep.mp. OR NREM sleep.mp. OR rhombencephalic sleep.mp. OR fast-wave sleep.mp. OR fast wave sleep.mp. OR paradoxical sleep.mp.	11,048
	8	Melatonin/ OR melatonin.mp. OR Illumination/ OR light.mp. OR lights.mp. OR lighting.mp. OR	24,238

		chronobiolog$.mp. OR biological clock$.mp. OR biologic clock$.mp. OR biologic$ oscillator$.mp. OR biologic$ pacemaker$.mp. OR endogenous oscillator$.mp. OR Human Biological Rhythms/ OR circadian rhythm$.mp. OR twenty-four hour rhythm.mp. OR twenty four hour rhythm.mp. OR ultradian rhythm.mp. OR diurnal rhythm.mp. OR nyctohemeral rhythm.mp. OR 24-hour rhythm.mp.	
	9	Wakefulness/ OR wakefulness.mp. OR Physiological Arousal/ OR arousal.mp. OR Vigilance/ OR vigilance.mp. OR arousal.mp.	33,866
	10	Sleep Deprivation/ OR sleep depriv$.mp. OR sleep fragmention.mp. OR (insufficien$ adj2 sleep).mp.	7,345
	11	somnolence.mp. OR hypersomn$.mp. OR Hypersomnia/ OR subwakefulness syndrome.mp. OR exp Sleep Disorders/ OR sleep disorder$.mp. OR sleep related neurogenic tachypnea.mp. OR sleep-related neurogenic tachypnea.mp. OR long sleeper syndrome.mp. OR short sleeper syndrome.mp. OR short sleep phenotype.mp.	1,109
	12	DIMS.mp. OR early awakening.mp. OR Insomnia/ OR insomnia.mp. OR Sleep Onset/ OR sleep onset.mp. OR sleep initiation.mp. OR sleep maintenance.mp. OR sleepless$.mp.	17,707
	13	4 OR 5 OR 6 OR 7 OR 8 OR 9 OR 10 OR 11 OR 12	122,953
P + O	14	3 AND 13	36,535
SD	15	TX Randomized controlled trial OR TX controlled clinical trial OR TX randomized OR TX trial OR TX evaluation OR TX program evaluation	516,702
Final	16	14 AND 15	3,406

Appendix 5 Predefined data extraction template

<table>
<tr><td colspan="7">Study ID No. #</td></tr>
<tr><td colspan="7">1. General information</td></tr>
<tr><td colspan="7">Title:</td></tr>
<tr><td colspan="5">Surname of first author:</td><td colspan="2">Year of study publication:</td></tr>
<tr><td colspan="7">Citation:</td></tr>
<tr><td colspan="7">Publication type: Journal Article ☐ Abstract ☐ Other (specify e.g. book chapter)___________________</td></tr>
<tr><td colspan="7">Ethical approval obtained for study: Yes ☐ No ☐ Unclear ☐</td></tr>
<tr><td colspan="7">2. Study characteristics</td></tr>
<tr><td>Methods</td><td>Study design:</td><td>Intervention setting:</td><td>Night work hours and shift system:</td><td colspan="2">Follow-up period (intervention plus follow-up):</td><td>(Washout period for cross-over trial):</td></tr>
<tr><td rowspan="2">Participants</td><td>Inclusion criteria:</td><td>Number screened:</td><td>Number included in this review:</td><td colspan="2">Age in years (mean (range)):</td><td>Country:</td></tr>
<tr><td>Exclusion criteria:</td><td>Number eligible:</td><td>Industry:</td><td colspan="2">Sex:</td><td>Study duration:</td></tr>
<tr><td>Interventions</td><td>Intervention:</td><td>Shift-based timing:</td><td>Hours of intervention:</td><td colspan="2">Dose/duration/frequency:</td><td>Control/comparison intervention:</td></tr>
<tr><td>Outcomes</td><td colspan="2">Sleepiness on-shift:
▪ Subjective:
▪ Objective:</td><td colspan="2">Sleep length off-shift:
▪ Subjective:
▪ Objective:</td><td colspan="2">Sleep quality off-shift:
▪ Subjective:
▪ Objective:</td></tr>
<tr><td>Notes</td><td colspan="6">Funding sources:</td></tr>
<tr><td colspan="7">3. Risk of bias</td></tr>
<tr><td colspan="3">Bias</td><td colspan="2">Judgement</td><td colspan="2">Support for judgement</td></tr>
<tr><td colspan="3">Random sequence generation (selection bias)</td><td colspan="2"></td><td colspan="2"></td></tr>
</table>

Allocation concealment (selection bias)		
Blinding of participants and personnel (performance bias)		
Blinding of outcome assessment (detection bias)		
Incomplete outcome data (attrition bias)		
Selective reporting (reporting bias)		
Other potential sources of bias		

Note. The data extraction and assessment template was developed by adopting and customizing the "Data collection form for intervention reviews: RCTs and non-RCTs" of the Cochrane Collaboration. New sections were added and irrelevant sections were removed from the original form.

Appendix 6 Extracted data of the included studies

1) Bjorvatn 2007

Study ID No. # 1	
4. General information	
Title: Randomized placebo-controlled field study of the effects of bright light and melatonin in adaptation to night work	
Surname of first author: Bjorvatn	Year of study publication: 2007
Citation: Bjorvatn, B., Stangenes, K., Oyane, N., Forberg, K., Lowden, A., Holsten, F., & Akerstedt, T. (2007). Randomized placebo-controlled field study of the effects of bright light and melatonin in adaptation to night work. Scand J Work Environ Health, 33(3), 204-214.	
Publication type: .....Journal Article ■	
Ethical approval obtained for study: Yes ■	
5. Study characteristics	
Methods	**Study design**: Randomized cross-over trial **Intervention setting**: Offshore oilrig **Night work hours and shift system**: Swing shift (two-week tour during which employees work 12-hour nights (18:30-06:30) the first seven days and 12-hour days (06:30-18:30) the second seven days, with a "swing day" (04:00-10:00) bridging the two weeks. The two weeks are followed by 3-4 weeks off, then the schedule is repeated) **Follow-up period (intervention plus follow-up)**: 9-10 weeks (2 weeks of intervention x 3 groups plus 3-4 week washout) **(Washout period)**: 3-4 weeks
Participants	**Inclusion criteria:** Problems adjusting to shift work (needing > 3 days to (re)adapt), or more than moderate sleep problems (based on authors' questionnaire) **Exclusion criteria:** None reported **Number screened:** 109 **Number eligible:** 38 **Number included in this review:** 17 **Industry:** Offshore oil industry **Age in** years (mean (range)): 42 (29-55) **Sex:** 94% male **Country:** Norway (North Sea)

	Study duration: April 2002 to April 2003		
Interventions	**Intervention:** Exposure to bright light via a light box **Shift-based timing:** Light: On-shift (night) **Hours of intervention:** Individualized timing starting two hours before the assumed nadir of the circadian phase and moved backward by one hour every day during night shift shift: between 00:00 and 05:00; during day shift: between 12:00 and 14:30) **Dose/duration/frequency:** 10,000 lux, 30 minutes per exposure, 1 exposure night, 8 exposures in total **Control/comparison intervention:** No bright light exposure		
Outcomes	**Sleepiness on-shift:** ▪ Subjective: Karolinska Sleepiness Scale, ATS Scale (shortened version) ▪ Objective: NR	**Sleep length off-shift:** ▪ Subjective: sleep diary ▪ Objective: wrist-worn actigraphy	**Sleep quality off-shift:** ▪ Subjective: sleep diary ▪ Objective: wrist-worn actigraphy
Notes	**Funding sources:** NR		

6. Risk of bias

Bias	**Judgement**	**Support for judgement**
Random sequence generation (selection bias)	Low	"...computer-generated method"
Allocation concealment (selection bias)	Low	"The randomization code was kept in sealed envelopes"
Blinding of participants and personnel (performance bias)	Unclear	Subjects blinded to medication (melatonin or placebo), but no information available on light treatment
Blinding of outcome assessment (detection bias)	Unclear	NR
Incomplete outcome data (attrition bias)	Unclear	"Of the 38 included persons, 17 completed the study (45%). The others did not participate or did not complete the study for the following reasons: (i) did not want to participate (8 persons), (ii) on sick leave (3 persons), (iii) stopped working this shift schedule (5 persons), (iv) quit or on leave (3

		persons), or dropped out (2 persons, 1 claiming the study protocol took too much time and 1 wanting to take melatonin regularly during the work periods)" "In order to retain as many participants as possible in the analysis, we replaced missing data with careful estimates. If data from, for example, night 3 were missing, an average of night 2 and 4 was inserted. If night 7 or day 7 was missing, night or day 6 was inserted. If night 1 or day 1 was missing, night 2 or day 2 was inserted. The total number of missing data that were corrected varied between 1.1% and 3.6%, except for the recorded intake of coffee and tea, for which 8.0% of the data were missing"
Selective reporting (reporting bias)	Low	All expected outcomes reported
Other potential sources of bias	Low	Adequate washout period was given

2) Chang 2015

Study ID No. # 2	
1. General information	
Title: Did a brief nap break have positive benefits on information processing among nurses working on the first 8-h night shift?	
Surname of first author: Chang	Year of study publication: 2015
Citation: Chang, Y. S., Wu, Y. H., Lu, M. R., Hsu, C. Y., Liu, C. K., & Hsu, C. (2015). Did a brief nap break have positive benefits on information processing among nurses working on the first 8-h night shift? Appl Ergon, 48, 104-108. doi:10.1016/j.apergo.2014.11.005	
Publication type: .....Journal Article ■	
Ethical approval obtained for study: Yes ■	
2. Study characteristics	
Methods	**Study design:** Randomized controlled trial **Intervention setting:** Healthcare **Night work hours and shift system:** 8-hour three-shift system; night work between 00:00-08:00

<table>
<tr><td></td><td colspan="3">Follow-up period (intervention plus follow-up): NR</td></tr>
<tr><td>Participants</td><td colspan="3">Inclusion criteria: NR
Exclusion criteria: those who reported any of the following characteristics on a screening questionnaire: current use of hypnotics, regular coffee-drinking, psychiatric illness, major systemic disease or sleep disorder
Number screened: NR
Number eligible: NR
Number included in this review: 63
Industry: Healthcare (nursing)
Age in years (mean (range)): 25.7±2.5
Sex: NR
Country: Taiwan
Study duration: NR</td></tr>
<tr><td>Interventions</td><td colspan="3">Intervention: Strategic naps
Shift-based timing: night (on-duty)
Hours of intervention: “…prophylactic nap between 7 and 11 p.m. or 30-min nap between 2 and 3 a.m. was a distance away from patient rooms and staff activity.”
Dose/duration/frequency: single 30-minute nap
Control/comparison intervention: no-nap</td></tr>
<tr><td>Outcomes</td><td>Sleepiness on-shift:
▪ Subjective: The Stanford Sleepiness Scale (SSS)
▪ Objective: NR</td><td>Sleep length off-shift: NR</td><td>Sleep quality off-shift: NR</td></tr>
<tr><td>Notes</td><td colspan="3">Funding sources: Kaohsiung Municipal Kai-Syuan Psychiatric Hospital</td></tr>
</table>

<table>
<tr><td colspan="3">3. Risk of bias</td></tr>
<tr><td>Bias</td><td>Judgement</td><td>Support for judgement</td></tr>
<tr><td>Random sequence generation (selection bias)</td><td>Unclear</td><td>NR</td></tr>
</table>

Allocation concealment (selection bias)	Low	"The subjects were randomly assigned into three group…"
Blinding of participants and personnel (performance bias)	Unclear	NR
Blinding of outcome assessment (detection bias)	Unclear	NR
Incomplete outcome data (attrition bias)	Unclear	NR
Selective reporting (reporting bias)	Unclear	NR
Other potential sources of bias	Low	Not relevant

3) Chang 2017

Study ID No. #	
1. General information	
Title: The Effects of Aromatherapy Massage on Sleep Quality of Nurses on Monthly Rotating Night Shifts	
Surname of first author: Chang	Year of study publication: 2017
Citation: Chang, Y. Y., Lin, C. L., & Chang, L. Y. (2017). The Effects of Aromatherapy Massage on Sleep Quality of Nurses on Monthly Rotating Night Shifts. Evid Based Complement Alternat Med, 2017, 3861273. doi:10.1155/2017/3861273	
Publication type: .....Journal Article ■	
Ethical approval obtained for study: Yes ■	
2. Study characteristics	

Methods	**Study design:** Randomized controlled trial **Intervention setting:** Healthcare **Night work hours and shift system:** NR **Follow-up period (intervention plus follow-up):** NR, but at least 5 weeks		
Participants	**Inclusion criteria:** (1) female nurses on monthly rotating shifts, (2) having a total PSQI ≥ 5, and (3) age between 20 and 50 years **Exclusion criteria:** (1) working fixed night or day shifts, (2) pregnancy, and (3) menopause. **Number screened:** NR **Number eligible:** 53 **Number included in this review:** 50 **Industry:** Healthcare (nursing) **Age in years (mean (range)):** 29.37 ± 5.37 (23–48) **Sex:** Female only **Country:** Taiwan **Study duration:** "After a week of the pretests, the data was collected for the following four weeks of the second graveyard shift."		
Interventions	**Intervention:** aromatherapy **Shift-based timing:** Day (off-duty) **Hours of intervention:** NR **Dose/duration/frequency:** The aromatherapist used the essential oil (*Organum majorana*) dripping into the heart Chakra (chest) to allow the subject to sense its scent and then gently rocked the body with essential oil and massage oil of the subject to promote relaxation of body muscle for the following 25 minutes. **Control/comparison intervention:** no-aromatherapy		
Outcomes	**Sleepiness on-shift:** NR	**Sleep length off-shift:** NR	**Sleep quality off-shift:** ▪ Subjective: The Pittsburgh Sleep Quality Index (PSQI) ▪ Objective: electrogardiogram (ECG) signal collector
Notes	**Funding sources:** Taichung Veterans General Hospital		
3. Risk of bias			

Bias	Judgement	Support for judgement
Random sequence generation (selection bias)	Low	"Randomization was assigned by a computer and information regarding group assignment was sealed in envelopes."
Allocation concealment (selection bias)	Low	"Subjects were randomly assigned into two groups." "At study termination, complete experimental data were successfully collected from 50 subjects, with 27 randomized to the treatment group and 23 to the control group."
Blinding of participants and personnel (performance bias)	Low	"Participants received the envelopes revealing the study group assignment."
Blinding of outcome assessment (detection bias)	Unclear	NR
Incomplete outcome data (attrition bias)	Low	"At study termination, complete experimental data were successfully collected…"
Selective reporting (reporting bias)	Low	All expected outcomes reported
Other potential sources of bias	Low	Not relevant

4) Griepentrog 2018

Study ID No. # 4	
1. General information	
Title: Bright environmental light improves the sleepiness of nightshift ICU nurses	
Surname of first author: Griepentrog	Year of study publication: 2018

<table>
<tr><td colspan="4">Citation: Griepentrog, J. E., Labiner, H. E., Gunn, S. R., & Rosengart, M. R. (2018). Bright environmental light improves the sleepiness of nightshift ICU nurses. Critical Care, 22(1), 295-304. doi:10.1186/s13054-018-2233-4</td></tr>
<tr><td colspan="4">Publication type: .....Journal Article ■</td></tr>
<tr><td colspan="4">Ethical approval obtained for study: Yes ■</td></tr>
<tr><td colspan="4">2. Study characteristics</td></tr>
<tr><td>Methods</td><td colspan="3">Study design: Randomized cross-over trial
Intervention setting: Healthcare
Night work hours and shift system: 12-hour two-shift system with night shift 19:00—07:00 hours
Follow-up period (intervention plus follow-up): 1 October 2017—1 December 2017
(Washout period for cross-over trial): NR</td></tr>
<tr><td>Participants</td><td colspan="3">Inclusion criteria: “nurses working a night shift (1900–0700 h) in the Surgical Trauma Intensive Care Unit (ICU) at the University of Pittsburgh Medical Center (UPMC) Presbyterian Hospital”
Exclusion criteria: NR
Number screened: NR
Number eligible: NR
Number included in this review: 43
Industry: Healthcare (nursing)
Age in years (mean (range)): 29 (26-32)
Sex: Both
Country: USA
Study duration: 4 weeks</td></tr>
<tr><td>Interventions</td><td colspan="3">Intervention: Controlled light exposure; ambient white, fluorescent hospital lighting (2,000 lux (lx), color temperature 3500–4100 K, 100% UV filtration);
Shift-based timing: night (on-duty)
Hours of intervention: 19:00—05:00
Dose/duration/frequency: Light exposure initiated at 19:00 and discontinued at 05:00, generating a 10-hour exposure period.
Control/comparison intervention: Standard ambient fluorescent lighting of the hospital during night work</td></tr>
<tr><td>Outcomes</td><td>Sleepiness on-shift:</td><td>Sleep length off-shift: NR</td><td>Sleep quality off-shift: NR</td></tr>
</table>

	▪ Subjective: The Stanford Sleepiness Scale (SSS) ▪ Objective: NR		
Notes	**Funding sources:** National Institutes of Health grant		

3. Risk of bias		
Bias	**Judgement**	**Support for judgement**
Random sequence generation (selection bias)	Unclear	NR
Allocation concealment (selection bias)	Low	"Allocation to either exposure was dictated by the monthly ICU nursing schedule, an established process to staff the ICU that has been performed for years and that occurred independent of our trial design and implementation."
Blinding of participants and personnel (performance bias)	Unclear	NR
Blinding of outcome assessment (detection bias)	Unclear	NR
Incomplete outcome data (attrition bias)	Unclear	NR
Selective reporting (reporting bias)	Low	All expected outcomes reported
Other potential sources of bias	Low	Not relevant

5) Harma 2006

Study ID No. # 5	
1. General information	
Title: A controlled intervention study on the effects of a very rapidly forward rotating shift system on sleep-wakefulness and well-being among young and elderly shift workers	
Surname of first author: Harma	Year of study publication: 2006
Citation: Harma, M., Tarja, H., Irja, K., Mikael, S., Jussi, V., Anne, B., & Pertti, M. (2006). A controlled intervention study on the effects of a very rapidly forward rotating shift system on sleep-wakefulness and well-being among young and elderly shift workers. Int J Psychophysiol, 59(1), 70-79. doi:10.1016/j.ijpsycho.2005.08.005	
Publication type: .....Journal Article ■	
Ethical approval obtained for study: Unclear ■	
2. Study characteristics	
Methods	**Study design:** Randomized controlled trial **Intervention setting:** Airline company **Night work hours and shift system:** 8-hour backward-rotating shift system; "a continuous backward rotating three-shift system with the shift order of EEE– –MMM– –NNN– – (E = evening shift, M = morning shift, N = night shift, – = free day). The shift changing times were mostly at 07:00, 15:00 and 23:00." **Follow-up period (intervention plus follow-up):** 2 years
Participants	**Inclusion criteria:** male technicians of the aircraft technical maintenance unit **Exclusion criteria:** NR **Number screened:** 273 **Number eligible:** NR **Number included in this review:** 137 **Industry:** Airline company (maintenance personnel) **Age in years (mean (range)):** **Sex:** Male only **Country:** Finland

<table>
<tr><td></td><td colspan="3">Study duration: April 2001—May 2003</td></tr>
<tr><td>Interventions</td><td colspan="3">Intervention: Shift schedule modification; 10-hour rapid forward-rotating shift
Shift-based timing: Not relevant
Hours of intervention: Not relevant
Dose/duration/frequency: “The measurements took place in both groups 1.5 years before (May–April in 2001) and 6 months after (May–April in 2003) the first installation of a new shift system.”
Control/comparison intervention:</td></tr>
<tr><td>Outcomes</td><td>Sleepiness on-shift:
▪ Subjective: Karolinska Sleepiness Scale (KSS)
▪ Objective: NR</td><td>Sleep length off-shift:
▪ Subjective: sleep diary
▪ Objective: wrist actigraphy</td><td>Sleep quality off-shift:
▪ Subjective: sleep diary
▪ Objective: wrist actigraphy</td></tr>
<tr><td>Notes</td><td colspan="3">Funding sources: EU-grant QLRT2000-00038 of the ‘‘Respect’’-program.</td></tr>
</table>

3. Risk of bias

Bias	Judgement	Support for judgement
Random sequence generation (selection bias)	Unclear	NR
Allocation concealment (selection bias)	High	It was not possible, however, to randomize workers to the intervention and control groups which means that the volunteers for the new shift system could be self-selected.
Blinding of participants and personnel (performance bias)	Unclear	NR
Blinding of outcome assessment (detection bias)	Low	To control possible additional learning effects, the data collection during the field measurements was started randomly on different days of the shift schedule
Incomplete outcome data(attrition bias)	Unclear	NR
Selective reporting (reporting bias)	Low	All expected outcomes reported
Other potential sources of bias	Low	Not relevant

6) Howard 2010

Study ID No. # 6	
1. General information	
Title: The effects of a 30-minute napping opportunity during an actual night shift on performance and sleepiness in shift workers	
Surname of first author: Howard	Year of study publication: 2010
Citation: Howard, M. E., Radford, L., Jackson, M. L., Swann, P., & Kennedy, G. A. (2010). The effects of a 30-minute napping opportunity during an actual night shift on performance and sleepiness in shift workers. Biological Rhythm Research, 41(2), 137-148. doi:10.1080/09291010903030946	
Publication type: .....Journal Article ■	
Ethical approval obtained for study: Yes ■	
2. Study characteristics	
Methods	**Study design:** Randomized cross-over trial **Intervention setting:** Sleep disorders research unit **Night work hours and shift system:** At least one night shift per fortnight during the six months preceding the study (21:00-07:00) **Follow-up period (intervention plus follow-up):** 1 night **(Washout period for cross-over trial):** Minimum of 2 weeks
Participants	**Inclusion criteria:** NR **Exclusion criteria:** Visual impairment that did not correct with eye-glasses; regularly used sedative medications; history of sleep apnoea or clinical features of sleep apnoea; chronic sleepiness (score greater than 10 on the Epworth Sleepiness Scale) **Number screened:** NR **Number eligible:** NR **Number included in this review:** 8 **Industry:** Sleep research **Age in years (mean (range)):** 31 ± 9.6 **Sex:** 75% female **Country:** Australia

	Study duration: NR		
Interventions	**Intervention:** Strategic naps **Shift-based timing:** Night (on-shift) **Hours of intervention:** 04:00 **Dose/duration/frequency:** 30 minutes per exposure, 1 exposure per night for 1 night **Control/comparison intervention:** Participants were requested not to sleep after 12:00 noon on each day of testing, and have a minimum of 7 hours sleep on the night prior to the session; Additional control group: nap in the evening, prior to the night shift		
Outcomes	**Sleepiness on-shift:** ▪ Subjective: Karolinska Sleepiness Scale (at baseline visit: 20:15 plus four times during shift: 20:15, 03:45, 04:30, 06:45) ▪ Objective: NR	**Sleep length off-shift:** NR	**Sleep quality off-shift:** NR
Notes	**Funding sources:** VicRoads		

3. Risk of bias

Bias	**Judgement**	**Support for judgement**
Random sequence generation (selection bias)	Unclear	"alternating sequence"
Allocation concealment (selection bias)	Unclear	NR
Blinding of participants and personnel (performance bias)	Unclear	NR
Blinding of outcome assessment (detection bias)	Unclear	NR
Incomplete outcome data (attrition bias)	Low	Participants completed all experimental conditions
Selective reporting	Low	All expected outcomes reported

(reporting bias)		
Other potential sources of bias	Unclear	"...sleep inertia...may have played a role in the lack of significant performance improvement following the morning nap in the current study"

7) Huang 2013

Study ID No. # 7	
1. General information	
Title: The effectiveness of light/dark exposure to treat insomnia in female nurses undertaking shift work during the evening/night shift	
Surname of first author: Huang	Year of study publication: 2013
Citation: Huang, L. B., Tsai, M. C., Chen, C. Y., & Hsu, S. C. (2013). The effectiveness of light/dark exposure to treat insomnia in female nurses undertaking shift work during the evening/night shift. J Clin Sleep Med, 9(7), 641-646. doi:10.5664/jcsm.2824	
Publication type: .....Journal Article ■	
Ethical approval obtained for study: Yes ■	
2. Study characteristics	
Methods	**Study design:** Randomized controlled trial **Intervention setting:** Healthcare **Night work hours and shift system:** Three-shift rotation (evening/night shift) **Follow-up period (intervention plus follow-up):** 14 days
Participants	**Inclusion criteria:** Rotating-shift female nurses working the evening/night shift; 3-shift rotation including day, evening, and night shifts in the most recent 6 months; pretreatment Insomnia Severity Index score > 14 (so, having clinical insomnia) **Exclusion criteria:** NR **Number screened:** NR **Number eligible:** NR **Number included in this review:** 102

	Industry: Healthcare (nursing) **Age in years (mean (range)):** (mean ± SD)**:** 30.2 ± 4.5 (intervention); 30.0 ± 4.7 (control) (n = 92) **Sex:** Female only **Country:** Taiwan **Study duration:** 1 May, 2009 to 31 March, 2010		
Interventions	**Intervention:** Exposure to bright light via a light box **Shift-based timing:** Light: night (on-shift) **Hours of intervention:** Between 23:00 and 00:00 **Dose/duration/frequency:** 7000-10,000 lux, ≥ 30 minutes per exposure, 1 exposure per night for 10-14 nights **Control/comparison intervention:** No bright light		
Outcomes	**Sleepiness on-shift:** ▪ Subjective: Insomnia Severity Index pre-intervention and post-intervention ▪ Objective: NR	**Sleep length off-shift:** NR	**Sleep quality off-shift:** NR
Notes	**Funding sources:** Chang Gung Memorial Hospital		

3. Risk of bias

Bias	**Judgement**	**Support for judgement**
Random sequence generation (selection bias)	Low	Randomization was performed using a random digit table
Allocation concealment (selection bias)	Unclear	NR
Blinding of participants and personnel (performance bias)	High	"This study was not a double-blind study. The subjects in both groups might work in the same unit, and the use of a sham light box (a light box of a much lower intensity or red light) in the control group would be able to be detected by the controls, who would discern the difference"
Blinding of outcome ssessment (detection bias)	Unclear	NR

Incomplete outcome data (attrition bias)	Low	Sleep quality: "A total of 92 rotating-shift female hospital nurses ...were recruited...forty-six subjects were in the treatment group, and the remainder were in the control group. All subjects completed the study procedure reported by themselves"
Selective reporting (reporting bias)	Low	All expected outcomes reported
Other potential sources of bias	Low	NR

8) Jarnefelt 2012

Study ID No. # 8	
1. General information	
Title: Cognitive behavior therapy for chronic insomnia in occupational health services	
Surname of first author: Jarnefelt	Year of study publication: 2012
Citation: Jarnefelt, H., Lagerstedt, R., Kajaste, S., Sallinen, M., Savolainen, A., & Hublin, C. (2012). Cognitive behavior therapy for chronic insomnia in occupational health services. J Occup Rehabil, 22(4), 511-521. doi:10.1007/s10926-012-9365-1	
Publication type: .....Journal Article ■	
Ethical approval obtained for study: Yes■	
2. Study characteristics	
Methods	**Study design:** Randomized controlled trial **Intervention setting:** Broadcasting company **Night work hours and shift system:** day/evening/night shifts (night hours: 23:00—06:00) **Follow-up period (intervention plus follow-up):** "The measurements were conducted at the following time points: start of waiting period (T0), prior to CBT-I (T1), after CBT-I (T2), 3-month follow-up (T3), and 6-month follow-up (T4)."
Participants	**Inclusion criteria:** had to be employed in full-time shift work. By shift work we meant work (including commuting) of which at least 2 h took place between 9 pm and 7 am, for at least six shifts in a period of 3 weeks; have non-organic insomnia with features of psychophysiological insomnia, and motivation to treat his/her insomnia with non-pharmacological methods

	Exclusion criteria: secondary insomnia largely explained by a non-assessed or untreated illness that could interfere with, or be worsened by the conduct of CBT-I; due to retire during the period of treatment or the measurements **Number screened:** 52 **Number eligible:** 32 **Number included in this review:** 26 **Industry:** Broadcasting company **Age in years (mean (range)):** 44.2 ± 8.8 **Sex:** Both **Country:** Finland **Study duration:** April 2008—March 2010		
Interventions	**Intervention:** Cognitive behavioral therapy for insomnia including group and individual sessions **Shift-based timing:** Not relevant **Hours of intervention:** Not relevant **Dose/duration/frequency:** Face-to-face group lecture (90-120min, 7); Face-to-face individual lecture (50 min, 1) **Control/comparison intervention:** No-CBT		
Outcomes	**Sleepiness on-shift:** NR	**Sleep length off-shift:** ▪ Subjective: sleep diary ▪ Objective: wrist actigraphy	**Sleep quality off-shift:** ▪ Subjective: sleep diary ▪ Objective: wrist actigraphy
Notes	**Funding sources:** Finnish Work Environment Fund		

3. Risk of bias

Bias	Judgement	Support for judgement
Random sequence generation (selection bias)	Unclear	NR
Allocation concealment (selection bias)	Low	"The integrity of the treatment allocations was ensured…"
Blinding of participants and personnel (performance bias)	Unclear	NR
Blinding of outcome assessment	Unclear	NR

(detection bias)		
Incomplete outcome data (attrition bias)	Unclear	NR
Selective reporting (reporting bias)	Low	All expected outcomes reported
Other potential sources of bias	Unclear	NR

9) Karchani 2011

Study ID No. # 9	
1. General information	
Title: Do bright-light shock exposures during breaks reduce subjective sleepiness in night workers?	
Surname of first author: Karchani	Year of study publication: 2011
Citation: Karchani, M., Kakooei, H., Yazdi, Z., & Zare, M. (2011). Do bright-light shock exposures during breaks reduce subjective sleepiness in night workers? Sleep and Biological Rhythms, 9, 95-102. doi:10.1111/j.1479-8425.2011.00490.x	
Publication type: .....Journal Article ■	
Ethical approval obtained for study: Yes ■	
2. Study characteristics	
Methods	**Study design:** Randomised cross-over trial **Intervention setting:** Metal production plant **Night work hours and shift system:** 2 morning shifts, 2 evening shifts, 2 night (22:00-06:00) shifts, 2 days off; repeat **Follow-up period (intervention plus follow-up):** 2 nights intervention, 2 nights control **(Washout period for cross-over trial):** 6 days
Participants	**Inclusion criteria:** NR

<table>
<tr><td></td><td colspan="3">Exclusion criteria: Disease and long-term drug use
Number screened: NR
Number eligible: 90
Number included in this review: 90
Industry: Metal production operation
Age in years (mean (range)): 30.34 ± 6.34 (Group 1); 30.49 ± 5.81 (Group 2)
Sex: Male only
Country: Iran
Study duration: NR</td></tr>
<tr><td>Interventions</td><td colspan="3">Intervention: Exposure to bright white light during work break via fluorescent ceiling bulbs
Shift-based timing: Night (on-shift)
Hours of intervention: 22:00, 00:00, 02:00, 04:00
Dose/duration/frequency: 2500-3000 lux, 15 minutes per exposure, 4 exposures per night for two nights
Control/comparison intervention: Normal light</td></tr>
<tr><td>Outcomes</td><td>Sleepiness on-shift:
▪ Subjective: Stanford Sleepiness Scale (every 2 hours: 23:00, 01:00, 03:00, 05:00)
▪ Objective: NR</td><td>Sleep length off-shift: NR</td><td>Sleep quality off-shift: NR</td></tr>
<tr><td>Notes</td><td colspan="3">Funding sources: The Research Department of Tehran University of Medical Sciences</td></tr>
</table>

<table>
<tr><td colspan="3">3. Risk of bias</td></tr>
<tr><td>Bias</td><td>Judgement</td><td>Support for judgement</td></tr>
<tr><td>Random sequence generation (selection bias)</td><td>Low</td><td>“Consenting participants were randomized into two groups...”</td></tr>
<tr><td>Allocation concealment (selection bias)</td><td>Low</td><td>“Consenting participants were randomized into two groups, labelled as Group 1 and Group 2. The forty-five participants in Group 1 received bright light during the two consecutive night shifts. The 45 participants in group 2 were exposed to normal light during the two night shifts. Then measurements were performed by examiners based on the exact time schedules. After a 6-day</td></tr>
</table>

Blinding of participants and personnel (performance bias)	High	"One limitation of our study was that the participants were completely informed about the study's goals and procedures which resulted in the lack of any real placebo effect. It is possible that this may have had an effect on the results"
Blinding of outcome assessment (detection bias)	Unclear	NR
Incomplete outcome data (attrition bias)	Low	"All of the workers participated in both stages"
Selective reporting (reporting bias)	Low	All expected outcomes reported
Other potential sources of bias	Low	"There was no significant difference in period effect and carry-over effect, which shows that primacy or subsequence of light encounter, has no effect on the final results in both groups"

10) Kim 2016

Study ID No. # 10	
1. General information	
Title: Inhalation Effects of Aroma Essential Oil on Quality of Sleep for Shift Nurses after Night Work	
Surname of first author: Kim	Year of study publication: 2016
Citation: Kim, W., & Hur, M. H. (2016). Inhalation Effects of Aroma Essential Oil on Quality of Sleep for Shift Nurses after Night Work. J Korean Acad Nurs, 46(6), 769-779. doi:10.4040/jkan.2016.46.6.769	
Publication type: .....Journal Article ■	
Ethical approval obtained for study: Yes ■	
2. Study characteristics	
Methods	**Study design:** Randomized controlled trial **Intervention setting:** Healthcare

<table>
<tr><td></td><td colspan="3">Night work hours and shift system: 8-hour rotating shift system; night duty refers to work between the hours of 23:00 to 07:00
Follow-up period (intervention plus follow-up): 5 months</td></tr>
<tr><td>Participants</td><td colspan="3">Inclusion criteria: those who work at night for at least 3 consecutive days, aged between 20-60, normal olfactory sense and hearing, no restriction on the change of body position during sleep
Exclusion criteria: history of medical problems such as mental illness, hypertension, diabetes; previously had side effects from aroma essential oils; currently taking medications that may cause incense (sleeping pills, asthma-related drugs, cold medicines, alcohol); taking analgesics during menstruation
Number screened: 73
Number eligible: 60
Number included in this review: 60
Industry: Healthcare (nursing)
Age in years (mean (range)): 20-60
Sex: Both
Country: Korea
Study duration: 1 June 2014—15 April 2015</td></tr>
<tr><td>Interventions</td><td colspan="3">Intervention: Aromatherapy; inhalation of 3 drops of Lavandula augustifolia essential oil for 3 min at a 10cm distance from nose
Shift-based timing: Not relevant
Hours of intervention: Day (off-duty)
Dose/duration/frequency: "…the participants in the experimental group were asked to inhale essential oil for 3 min at a distance of approximately 10 cm from their nose and then they were asked to sleep with the aroma stone beside their head (within a 30 cm distance)" for 3 days
Control/comparison intervention: no-aromatherapy</td></tr>
<tr><td>Outcomes</td><td>Sleepiness on-shift: NR</td><td>Sleep length off-shift:
▪ Subjective: NR
▪ Objective: Wrist actigraphy</td><td>Sleep quality off-shift:
▪ Subjective: Numeric rating scale (NRS), The Verran & Synder-Halpern (VSH) sleep scale
▪ Objective: Wrist actigraphy</td></tr>
<tr><td>Notes</td><td colspan="3">Funding sources: National Research Foundation of Korea (NRF)</td></tr>
<tr><td colspan="4">3. Risk of bias</td></tr>
</table>

Bias	Judgement	Support for judgement
Random sequence generation (selection bias)	Low	"The subjects were randomly assigned to two groups using random number generation from Excel function…"
Allocation concealment (selection bias)	Low	Random allocation was used to determine experimental and control groups
Blinding of participants and personnel (performance bias)	Unclear	NR
Blinding of outcome assessment (detection bias)	Low	Researchers were blinded from subjects
Incomplete outcome data (attrition bias)	Unclear	NR
Selective reporting (reporting bias)	Low	All expected outcomes reported
Other potential sources of bias	Low	Power analysis was performed

11) Lee 2014

Study ID No. # 11	
1. General information	
Title: Home-based behavioral sleep training for shift workers: a pilot study	
Surname of first author: Lee	Year of study publication: 2014
Citation: Lee, K. A., Gay, C. L., & Alsten, C. R. (2014). Home-based behavioral sleep training for shift workers: a pilot study. Behav Sleep Med, 12(6), 455-468. doi:10.1080/15402002.2013.825840	
Publication type: .....Journal Article ■	
Ethical approval obtained for study: Unclear ■	
2. Study characteristics	
Methods	**Study design:** Randomized controlled trial

<table>
<tr><td></td><td colspan="3">Intervention setting: Healthcare
Night work hours and shift system:
Follow-up period (intervention plus follow-up): 11 weeks</td></tr>
<tr><td>Participants</td><td colspan="3">Inclusion criteria: “To be eligible, respondents had to (a) be a nurse working nights full time for at least 6 months, (b) be scheduled to work night shift at least 2 consecutive nights per week over the next 3 months, and (c) rate their sleep as poor (defined as a score below 5 on a 0–10 scale, with 10 D perfect sleep) for the past month”
Exclusion criteria: “…a current diagnosis of sleep disorder (e.g., apnea, narcolepsy, or restless legs) or mood disorder were excluded.”
Number screened: NR
Number eligible: 34
Number included in this review: 21
Industry: Healthcare (nursing)
Age in years (mean (range)): 45.5±12.5 (24–67)
Sex: Both
Country: USA
Study duration: 4 weeks</td></tr>
<tr><td>Interventions</td><td colspan="3">Intervention: Cognitive behavioral therapy-based sleep enhancement training; (1) Sleep enhancement training guideline booklet, (2) Sound-enhanced relaxation training
Shift-based timing: Not relevant
Hours of intervention: Not relevant
Dose/duration/frequency: NR
Control/comparison intervention: no-behavioral training</td></tr>
<tr><td>Outcomes</td><td>Sleepiness on-shift: NR</td><td>Sleep length off-shift:
▪ Subjective: The Pittsburgh Sleep Quality Index (PSQI), the General Sleep Disturbance Scale (GSDS), sleep diary
▪ Objective: Wrist actigraphy</td><td>Sleep quality off-shift:
▪ Subjective: The Pittsburgh Sleep Quality Index (PSQI), the General Sleep Disturbance Scale (GSDS), the Standard Shiftwork Index (SSI), sleep diary
▪ Objective: Wrist actigraphy</td></tr>
<tr><td>Notes</td><td colspan="3">Funding sources: The National Institutes of Health</td></tr>
</table>

3. Risk of bias		
Bias	**Judgement**	**Support for judgement**
Random sequence generation (selection bias)	Unclear	NR
Allocation concealment (selection bias)	Unclear	NR
Blinding of participants and personnel (performance bias)	Unclear	NR
Blinding of outcome assessment (detection bias)	Unclear	NR
Incomplete outcome data (attrition bias)	Unclear	Number screened and eligible not reported
Selective reporting (reporting bias)	Low	All expected outcomes reported
Other potential sources of bias	Low	Not relevant

12) Lowden 2004

Study ID No. # 12	
1. General information	
Title: Suppression of sleepiness and melatonin by bright light exposure during breaks in night work	
Surname of first author: Lowden	Year of study publication: 2004
Citation: Lowden, A., Akerstedt, T., & Wibom, R. (2004). Suppression of sleepiness and melatonin by bright light exposure during breaks in night work. J Sleep Res, 13(1), 37-43.	
Publication type: .....Journal Article ■	
Ethical approval obtained for study: Yes ■	
2. Study characteristics	
Methods	**Study design:** Randomized cross-over trial

<table>
<tr><td></td><td colspan="3">Intervention setting: Truck production plant
Night work hours and shift system: Four consecutive 5-day weeks of night shifts (00:00-06:30). Weekends off. Night shifts 6.5 hours long except for the first shift of each week, which started at 21:45 hours (Sunday evening) and lasted 8.75 hours
Follow-up period (intervention plus follow-up): Intervention: 15 days
(Washout period for cross-over trial): NR, possibly 3 months (“One group obtained...bright light...in the spring...a similar treatment in autumn”)</td></tr>
<tr><td>Participants</td><td colspan="3">Inclusion criteria: NR
Exclusion criteria: NR
Number screened: 24
Number eligible: NR
Number included in this review: 18
Industry: Truck production operation
Age in years (mean (range)): 36.2 (24-56)
Sex: Both
Country: Sweden
Study duration: “spring” and “autumn”</td></tr>
<tr><td>Interventions</td><td colspan="3">Intervention: Exposure to bright light via fluorescent ceiling tubes in break room
Shift-based timing: On-shift (night)
Hours of intervention: During break. Workers were permitted 2 short breaks at night (2 x 10 min. (plus an additional 10 min. on Mondays)), but were also allowed to leave workstation for shorter periods. The timing of breaks was self-chosen
Dose/duration/frequency: 2500 lux, 10 minutes per exposure, 2 exposures per night for 15 nights
Control/comparison intervention: Normal light during break</td></tr>
<tr><td>Outcomes</td><td>Sleepiness on-shift:
▪ Subjective: Karolinska Sleepiness Scale: every 2 hours on-shift; Karolinska Sleep Diary: daily, at the end of the day
▪ Objective: NR</td><td>Sleep length off-shift:
▪ Subjective: Karolinska Sleep Diary: daily, at the end of the day
▪ Objective: Actigraphy: during each week studied. Worn during three free weekends in connection to night work</td><td>Sleep quality off-shift:
▪ Subjective: Karolinska Sleep Diary: daily, at the end of the day
▪ Objective: Actigraphy: during each week studied. Worn during three free weekends in connection to night work</td></tr>
</table>

Notes	**Funding sources:** The Swedish Work Environment Fund and the Volvo Powertrain Co-operation

3. Risk of bias		
Bias	**Judgement**	**Support for judgement**
Random sequence generation (selection bias)	Low	The workers "were assigned to two groups (blocked randomization using cards) for the order of treatment presentation"
Allocation concealment (selection bias)	Unclear	NR
Blinding of participants and personnel (performance bias)	High	"The subjects in the present study were aware of the two conditions and thus the study lacked a true placebo condition. It is likely that this could have influenced the results"
Blinding of outcome assessment (detection bias)	Unclear	NR
Incomplete outcome data (attrition bias)	Unclear	"As some workers showed missing data on Fridays, this day was omitted from the analysis."
Selective reporting (reporting bias)	Low	All expected outcomes reported
Other potential sources of bias	Low	"Workers were randomly assigned to two groups in a cross-over design. One group obtained BL in the spring and the other group received normal indoor light (NL). A similar treatment was undertaken in the autumn"

13) Oriyama 2014

Study ID No. # 13	
1. General information	
Title: Effects of two 15-min naps on the subjective sleepiness, fatigue and heart rate variability of night shift nurses	
Surname of first author: Oriyama	Year of study publication: 2014
Citation: Oriyama, S., Miyakoshi, Y., & Kobayashi, T. (2014). Effects of two 15-min naps on the subjective sleepiness, fatigue and heart rate variability of night shift nurses. Ind Health, 52(1), 25-35.	
Publication type: .....Journal Article ■	

Ethical approval obtained for study: Yes ■			
2. Study characteristics			
Methods	**Study design:** Randomized controlled trial **Intervention setting:** Healthcare **Night work hours and shift system:** Three-shift system, with 7-8 night shifts every month Night shift "8-h": either 00:00-08:45 or 00:30-09:15. The day before the night shift was a day-off. Study carried out on the first "day" of the night shift. Break of 60 minutes allowed between 01:00 and 06:00, either all at once or divided up **Follow-up period (intervention plus follow-up):** 1 night		
Participants	**Inclusion criteria:** NR **Exclusion criteria:** NR **Number screened:** NR **Number eligible:** NR **Number included in this review:** 15 **Industry:** Healthcare (nursing) **Age in years (mean (range)):** (mean ± SD): 23.00 ± .92 (intervention); 23.71 ± 1.88 (control) (P = 0.46) **Sex:** Female only **Country:** Japan **Study duration:** NR		
Interventions	**Intervention:** Strategic naps **Shift-based timing:** Night (on-shift) **Hours of intervention:** between 02:30 and 03:30 and between 04:30 and 05:45 **Dose/duration/frequency:** 15 minutes per exposure/2 exposures per night for 1 night **Control/comparison intervention:** No-nap		
Outcomes	**Sleepiness on-shift:** ▪ Subjective: VAS: approximately 10 measurements total, taken at hourly intervals, from 00:00, or 00:30, until 09:00 ▪ Objective: NR	**Sleep length off-shift:** NR	**Sleep quality off-shift:** NR

Notes	**Funding sources:** Ministry of Education, Culture, Sports, Science, and Technology of Japan	
3. Risk of bias		
Bias	**Judgement**	**Support for judgement**
Random sequence generation (selection bias)	Low	"The nurses were randomly allocated to the two (Nap and No-nap condition) groups"
Allocation concealment (selection bias)	Unclear	NR
Blinding of participants and personnel (performance bias)	Unclear	NR
Blinding of outcome assessment (detection bias)	Unclear	NR
Incomplete outcome data (attrition bias)	Unclear	N= 15 included in all analyses. No mention of any (relevant) missings or exclusions, but number screened and eligible not reported
Selective reporting (reporting bias)	Low	All expected outcomes reported
Other potential sources of bias	Low	Not relevant

14) Pylkkonen 2018

Study ID No. # 14	
1. General information	
Title: Effects of alertness management training on sleepiness among long-haul truck drivers: A randomized controlled trial	
Surname of first author: Pylkkonen	Year of study publication: 2018
Citation: Pylkkonen, M., Tolvanen, A., Hublin, C., Kaartinen, J., Karhula, K., Puttonen, S., . . . Sallinen, M. (2018). Effects of alertness management training on sleepiness among long-haul truck drivers: A randomized controlled trial. Accid Anal Prev, 121, 301-313. doi:10.1016/j.aap.2018.05.008	
Publication type: .....Journal Article ■	
Ethical approval obtained for study: Yes ■	
2. Study characteristics	
Methods	**Study design:** Randomized controlled trial **Intervention setting:** Domestic middle-sized logistic companies **Night work hours and shift system:** shift hours (morning, day, evening and/or night evening shifts); hours not specified **Follow-up period (intervention plus follow-up): "**The baseline measurements were conducted 5–6 months before (November 2010–April 2011) and the follow-up measurements 4–5 months after (November 2011–March 2012) the intervention" "The mean duration of the time between baseline and follow-up measurements was 362 (range 313–431) days."
Participants	**Inclusion criteria:** Truck drivers working shift hours (morning, day, evening and/or night evening shifts) **Exclusion criteria:** NR **Number screened:** 677 **Number eligible:** 54 **Number included in this review:** 52 **Industry:** Four domestic middle-sized logistic companies (truck drivers) **Age in years (mean (range)):** NR **Sex:** NR **Country:** Finland **Study duration:** March 2010—March 2012

Interventions	**Intervention:** Alertness management training— "The training aimed at promoting safe, economic, and environmentally friendly driving by optimizing driver alertness at the wheel." **Shift-based timing:** Not relevant **Hours of intervention:** Not relevant **Dose/duration/frequency:** Two 45-minute face-to-face lecture, single 60-minute workshop **Control/comparison intervention:** no-training program		
Outcomes	**Sleepiness on-shift:** ▪ Subjective: KSS ▪ Objective: NR	**Sleep length off-shift:** NR	**Sleep quality off-shift:** NR
Notes	**Funding sources:** Finnish Work Environment Fund, SalWe Research Program for Mind and Body, NordForsk, Nordic Program on Health and Welfare		

3. Risk of bias

Bias	**Judgement**	**Support for judgement**
Random sequence generation (selection bias)	Low	"The randomization process was carried out by a statistician outside the research group and the random allocation sequence was generated by a computer random number generator (SAS Power Procedure)."
Allocation concealment (selection bias)	Low	"The allocation ratio for the two parallel study groups was 32:21, respectively." "… the study groups were balanced using the stratified randomization method"
Blinding of participants and personnel (performance bias)	High	"Blinding the participants and those administering the intervention to group assignment was not possible in practice…" "…the study is lacking blinding. This type of deficit is known to increase the risk of performance and detection bias…"
Blinding of outcome assessment (detection bias)	High	"The outcome assessors were not blinded to group assignment either." "…the study is lacking blinding. This type of deficit is known to increase the risk of performance and detection bias…"
Incomplete outcome data (attrition bias)	Low	"the rates of those lost to follow-up between the two study groups were compared. No statistically significant difference was found at the rates of loss-to-follow-up between the groups, the drop-out being slightly greater in the intervention than in the control group."
Selective reporting (reporting bias)	Low	All expected outcomes reported

Other potential sources of bias	Low	NR

15) Rahman 2013

Study ID No. # 15	
1. General information	
Title: Effects of filtering visual short wavelengths during nocturnal shiftwork on sleep and performance	
Surname of first author: Rahman	Year of study publication: 2013
Citation: Rahman, S. A., Shapiro, C. M., Wang, F., Ainlay, H., Kazmi, S., Brown, T. J., & Casper, R. F. (2013). Effects of filtering visual short wavelengths during nocturnal shiftwork on sleep and performance. Chronobiol Int, 30(8), 951-962. doi:10.3109/07420528.2013.789894	
Publication type: .....Journal Article ■	
Ethical approval obtained for study: Yes ■	
2. Study characteristics	
Methods	**Study design:** Randomized controlled trial **Intervention setting:** Healthcare **Night work hours and shift system:** Participants did not rotate between night and day shifts during the 2-wk stretch, i.e., the subjects completed 2 wks of night shifts alternating with 2 wks of day shifts. All work shifts were separated by two to three non-working days during both night and day shift stretches. **Follow-up period (intervention plus follow-up):** 8 weeks **(Washout period for cross-over trial):** 2 weeks
Participants	**Inclusion criteria:** full-time nurses working different rotating shifts at the same hospital **Exclusion criteria:** extreme chronotype as assessed with the composite scale of morningness (exclusion range: 522 and 444; mean±SD: 34.2±4.3; range: 29–43);history of ocular/vision diseases including requirement of corrective lenses for vision and/or

	color blindness; depressive symptomatology based on the Center for Epidemiologic Studies Depression Scale (CES-D) score (exclusion 416; mean±SD: 8.4±3.3; range: 2–14); any medication use; and occasional or habitual nicotine use **Number screened:** 36 **Number eligible:** 14 **Number included in this review:** 9 **Industry:** Healthcare (nursing) **Age in years (mean (range)):** 31.3±4.6 **Sex:** Both **Country:** Canada **Study duration:** NR		
Interventions	**Intervention:** Short-wavelength light protection; "…glasses fitted with short-wavelength filters (0% transmission 5480 nm) to be used only during night shifts during weeks 3 and 4 (days 15–28) or 7 and 8 (days 43–56)." **Shift-based timing:** 19:30–07:30 **Hours of intervention:** Night (on-duty) **Dose/duration/frequency:** light protection for the whole night work hour duration **Control/comparison intervention:** exposed to standard unfiltered ambient artificial light		
Outcomes	**Sleepiness on-shift:** ▪ Subjective: The Epworth Sleepiness Scale (ESS) ▪ Objective: NR	**Sleep length off-shift:** ▪ Subjective: daily sleep diary ▪ Objective: Polysomnography (PSG) using the Sandman Elite system (Kanata, Ontario, Canada)	**Sleep quality off-shift:** ▪ Subjective: daily sleep diary ▪ Objective: Polysomnography (PSG) using the Sandman Elite system (Kanata, Ontario, Canada)
Notes	**Funding sources:** Canadian Institutes of Health Research Operating Grant		

3. Risk of bias

Bias	Judgement	Support for judgement
Random sequence generation (selection bias)	Low	The first exposure to the sleep laboratory was randomized between baseline (five subjects) and intervention (four subjects) to control for any acclimatization and first night effects.
Allocation concealment (selection bias)	Low	"Participants were randomized to receive filtered light (intervention) or standard indoor light (baseline) on night shifts."

Blinding of participants and personnel (performance bias)	Unclear	NR
Blinding of outcome assessment (detection bias)	Unclear	NR
Incomplete outcome data (attrition bias)	High	"…there was considerable loss of data (~37%) across all participants due to noncompliance with daily reporting…"
Selective reporting (reporting bias)	Low	All expected outcomes reported
Other potential sources of bias	Low	Not relevant

16) Ross 1995

Study ID No. # 16	
1. General information	
Title: Night-shift work in Antarctica: sleep characteristics and bright light treatment	
Surname of first author: Ross	Year of study publication: 1995
Citation: Ross, J. K., Arendt, J., Horne, J., & Haston, W. (1995). Night-shift work in Antarctica: sleep characteristics and bright light treatment. Physiol Behav, 57(6), 1169-1174.	
Publication type: .....Journal Article ■	
Ethical approval obtained for study: Unclear ■	
2. Study characteristics	
Methods	**Study design:** Randomized controlled trial **Intervention setting:** Antarctic research base **Night work hours and shift system:** One week of night shift **Follow-up period (intervention plus follow-up):** 5 weeks (1 week prior to night shift, 1 week of night shift and the first, second, and third weeks after night shift)
Participants	**Inclusion criteria:** NR **Exclusion criteria:** NR

	Number screened: NR **Number eligible:** NR **Number included in this review:** 13 **Industry:** Geophysical research **Age in years (mean (range)):** 21-35 **Sex:** Male only **Country:** Antarctica **Study duration:** Late March to mid-September		
Interventions	**Intervention:** Exposure to full-spectrum white light **Shift-based timing:** On-shift (day) **Hours of intervention:** 11:00-13:00 **Dose/duration/frequency:** 2500-3000 lux, 2 hours per exposure, 1 exposure per day for 7 days **Control/comparison intervention:** Exposure to dim light		
Outcomes	**Sleepiness on-shift:** ▪ Subjective: VAS: towards the end of each day ▪ Objective: NR	**Sleep length off-shift:** ▪ Subjective: Sleep log: Daily throughout study ▪ Objective: NR	**Sleep quality off-shift:** ▪ Subjective: Sleep log: Daily throughout study; Sleep quality scale: Daily ▪ Objective: NR
Notes	**Funding sources:** Supported by the British Antarctic Survey		

3. Risk of bias

Bias	**Judgement**	**Support for judgement**
Random sequence generation (selection bias)	Unclear	NR
Allocation concealment (selection bias)	Low	"Subjects were randomly allocated to receive bright (2,500-3,000 lx) full spectrum white light (N -- 9) or dim (<500 lx) red light (N = 7) for 2 h (ll00-1300 h) each day of the third week (i.e., during the first week after night-shift)."
Blinding of participants and personnel (performance bias)	Unclear	NR

Blinding of outcome assessment (detection bias)	Unclear	NR
Incomplete outcome data (attrition bias)	Low	One (subject) did not complete any sleep logs, but otherwise participated fully White light group n = 8, dim light group n = 7, except week 1 where incomplete data were obtained from two subjects (one in each group)
Selective reporting (reporting bias)	Low	All expected outcomes reported
Other potential sources of bias	High	"Two subjects appear twice in the study, each time in a different treatment group, due to the nature of the base rota. They are treated as separate subject-period data in the data analysis"

17) Sadeghniiat-Haghighi 2011

Study ID No. # 17	
1. General information	
Title: The effect of bright light on sleepiness among rapid-rotating 12-hour shift workers	
Surname of first author: Sadeghniiat-Haghighi	Year of study publication: 2011
Citation: Sadeghniiat-Haghighi, K., Yazdi, Z., Jahanihashemi, H., & Aminian, O. (2011). The effect of bright light on sleepiness among rapid-rotating 12-hour shift workers. Scand J Work Environ Health, 37(1), 77-79.	
Publication type: .....Journal Article ■	
Ethical approval obtained for study: Unclear ■	
2. Study characteristics	
Methods	**Study design:** Randomized cross-over trial **Intervention setting:** Ceramic factory **Night work hours and shift system:** Two 12-hour day shifts (06:00-18:00) followed by two days off-work, and then two 12-hour night shifts (18:00-06:00); the schedule was then repeated. Average working time per month was 220 hours

	Follow-up period (intervention plus follow-up): Not entirely clear if intervention lasted only one night (of the two night shifts) or both nights **(Washout period for cross-over trial):** 4 days		
Participants	**Inclusion criteria:** NR **Exclusion criteria:** NR **Number screened:** 97 **Number eligible:** 97 **Number included in this review:** 94 **Industry:** Ceramic production plant **Age in years (mean (range)):** 33 (21-45) **Sex:** Male only **Country:** Iran **Study duration:** NR		
Interventions	**Intervention:** Exposure to full-spectrum white light via fluorescent ceiling tubes in break room **Shift-based timing:** Night (on-shift) **Hours of intervention:** 00:30 and 02:30 **Dose/duration/frequency:** 2500 lux, 20 minutes per exposure, 2 exposures per night for 1 night **Control/comparison intervention:** Normal light (300 lux) during breaks. Break room similar with respect to temperature, color, and general ambience		
Outcomes	**Sleepiness on-shift:** ▪ Subjective: Stanford Sleepiness Scale (SSS): every two hours between 22:00 and 04:00 ▪ Objective: NR	**Sleep length off-shift:** NR	**Sleep quality off-shift:** NR
Notes	**Funding sources:** NR		

3. Risk of bias

Bias	Judgement	Support for judgement
Random sequence generation (selection bias)	Unclear	NR

Allocation concealment (selection bias)	Unclear	NR
Blinding of participants and personnel (performance bias)	High	"One limitation of this study was that the participants were aware of the two conditions and thus the study lacked a true placebo condition. It is possible that this may have had an effect on the results"
Blinding of outcome assessment (detection bias)	Unclear	NR
Incomplete outcome data (attrition bias)	Low	Three workers had to be excluded from the final analysis due to personal reasons
Selective reporting (reporting bias)	Low	All expected outcomes reported
Other potential sources of bias	Unclear	NR

18) Sallinen 1998

Study ID No. # 18	
1. General information	
Title: Promoting alertness with a short nap during a night shift	
Surname of first author: Sallinen	Year of study publication: 1998
Citation: Sallinen, M., Harma, M., Akerstedt, T., Rosa, R., & Lillqvist, O. (1998). Promoting alertness with a short nap during a night shift. J Sleep Res, 7(4), 240-247.	
Publication type: .....Journal Article ■	
Ethical approval obtained for study: Unclear ■	

2. Study characteristics			
Methods	**Study design:** Randomized cross-over trial **Intervention setting:** Oil rig refinery **Night work hours and shift system:** four morning shifts, one day off, four night shifts (23:00-07:10), one day off, and evening shifts. **Follow-up period (intervention plus follow-up):** **(Washout period for cross-over trial):**		
Participants	**Inclusion criteria:** NR **Exclusion criteria:** NR **Number screened:** NR **Number eligible:** NR **Number included in this review:** 14 **Industry:** Oil rig **Age in years (mean (range)):** 31-52 **Sex:** Male only **Country:** USA **Study duration:** 4 days		
Interventions	**Intervention:** Strategic naps **Shift-based timing:** Night (on-duty) **Hours of intervention:** at 01:50 or 04:40 **Dose/duration/frequency:** "…contained a nap which was either 50 or 30 min long ending either at 01.50 or 04.40 hours" **Control/comparison intervention:** no-nap		
Outcomes	**Sleepiness on-shift:** ▪ Subjective: the KSS ▪ Objective: NR	**Sleep length off-shift:** ▪ Subjective: NR ▪ Objective: Polysomnography	**Sleep quality off-shift:** ▪ Subjective: NR ▪ Objective: Polysomnography
Notes	**Funding sources:** the Finnish Work Environment Fund		

3. Risk of bias		
Bias	**Judgement**	**Support for judgement**

Random sequence generation (selection bias)	Unclear	NR
Allocation concealment (selection bias)	Unclear	NR
Blinding of participants and personnel (performance bias)	Unclear	NR
Blinding of outcome assessment (detection bias)	Unclear	NR
Incomplete outcome data (attrition bias)	Low	All participants provided data at the follow-up
Selective reporting (reporting bias)	Low	All expected outcomes reported
Other potential sources of bias	Low	Not relevant

19) Scott 2010

Study ID No. # 19	
1. General information	
Title: An interventional approach for patient and nurse safety: a fatigue countermeasures feasibility study	
Surname of first author: Scott	Year of study publication: 2010
Citation: Scott, L. D., Hofmeister, N., Rogness, N., & Rogers, A. E. (2010). An interventional approach for patient and nurse safety: a fatigue countermeasures feasibility study. Nurs Res, 59(4), 250-258. doi:10.1097/NNR.0b013e3181de9116	
Publication type: .....Journal Article ■	

Ethical approval obtained for study: Unclear ■			
2. Study characteristics			
Methods	**Study design:** Randomized controlled trial **Intervention setting:** Healthcare **Night work hours and shift system:** **Follow-up period (intervention plus follow-up):**		
Participants	**Inclusion criteria:** participants had to be full-time staff nurses (working at least 36 hr per week) practicing on the selected units and covering night work hours **Exclusion criteria:** nurses not involved in night work (advanced practice nurses, nurse managers, or nurses in specialized roles such as discharge planning) were not eligible to participate **Number screened:** 147 **Number eligible:** 62 **Number included in this review:** 62 **Industry:** Healthcare (nursing) **Age in years (mean (range)):** 37.74±11.70 (22-63) **Sex:** Both **Country:** USA **Study duration:** 3 months		
Interventions	**Intervention:** Fatigue countermeasure program: (a) education and training, (b) compliance with hours of service regulations, (c) appropriate scheduling practices, (d) countermeasures that can be instituted in the work setting, (e) design (e.g., ergonometrics) and technology (e.g., fail-safe designs), and (f) research **Shift-based timing:** Not relevant **Hours of intervention:** Not relevant **Dose/duration/frequency:** Single 60-minute face-to-face lecture **Control/comparison intervention:** No-fatigue countermeasure program		
Outcomes	**Sleepiness on-shift:** ▪ Subjective: The Epworth Sleepiness Scale (ESS) ▪ Objective: NR	**Sleep length off-shift:** ▪ Subjective: sleep diary ▪ Objective: NR	**Sleep quality off-shift:** ▪ Subjective: The Pittsburgh Sleep Quality Index (PSQI) ▪ Objective: NR

Notes	**Funding sources:** NR	
3. Risk of bias		
Bias	**Judgement**	**Support for judgement**
Random sequence generation (selection bias)	Unclear	NR
Allocation concealment (selection bias)	Unclear	NR
Blinding of participants and personnel (performance bias)	Unclear	NR
Blinding of outcome assessment (detection bias)	Unclear	NR
Incomplete outcome data (attrition bias)	Low	All participants provided data at the follow-up
Selective reporting (reporting bias)	Low	All expected outcomes reported
Other potential sources of bias	Low	"A power analysis was completed using established methods and definitions." "…there was sufficient statistical power to examine the variables of interest…"

20) Sletten 2017

Study ID No. # 20	
1. General information	
Title: Randomised controlled trial of the efficacy of a blue-enriched light intervention to improve alertness and performance in night shift workers	
Surname of first author: Sletten	Year of study publication: 2017
Citation: Sletten, T. L., Ftouni, S., Nicholas, C. L., Magee, M., Grunstein, R. R., Ferguson, S., . . . Rajaratnam, S. M. W. (2017). Randomised controlled trial of the efficacy of a blue-enriched light intervention to improve alertness and performance in night shift workers. Occup Environ Med, 74(11), 792-801. doi:10.1136/oemed-2016-103818	
Publication type: .....Journal Article ■	

Ethical approval obtained for study: Yes ■			
2. Study characteristics			
Methods	**Study design:** Randomized controlled trial **Intervention setting:** NR **Night work hours and shift system:** **Follow-up period (intervention plus follow-up):** **(Washout period for cross-over trial):**		
Participants	**Inclusion criteria:** working ≥4 night shifts per month, shift duration ≤12 hours and at least 6 hours worked between 22:00 hours and 08:00 hours; free of unstable medical or psychiatric conditions and medications considered to place them at increased risk due to sleep deprivation or light exposure; had not undergone transmeridian travel in the prior month; no major visual impairments and were not color blind **Exclusion criteria:** consumed extreme amounts of caffeine (>300 mg/day) or alcohol (>14 units/week) **Number screened:** 908 **Number eligible:** 83 **Number included in this review:** 71 **Industry:** NR **Age in years (mean (range)):** 32.8±10.5 **Sex:** Both **Country:** Australia **Study duration:** 7-17 days		
Interventions	**Intervention:** Controlled light exposure; 750 lux blue-enriched white light (17 000 K; 36W PL-L ActiViva in Melbourne and Adelaide, 54W TL5 ActiViva in Sydney) **Shift-based timing:** Night (on-shift) **Hours of intervention:** from 23:00 hours to 07:00 hours **Dose/duration/frequency:** 750 lux, 8-hour per exposure, 1 continuous exposure per night, 1-2 weeks **Control/comparison intervention:** standard spectrum light (4000 K; 36W PL-L 840 in Melbourne and Adelaide, 54W TL5 840 in Sydney)		
Outcomes	**Sleepiness on-shift:** ▪ Subjective: KSS	**Sleep length off-shift:** ▪ Subjective: daily sleep diary	**Sleep quality off-shift:** ▪ Subjective: daily sleep diary

	▪ Objective: NR	▪ Objective: wrist-worn Actigraphy	▪ Objective: wrist-worn Actigraphy
Notes	**Funding sources:** National Health and Medical Research Council (NHMRC) project grant		

3. Risk of bias		
Bias	**Judgement**	**Support for judgement**
Random sequence generation (selection bias)	Low	"Participants were assigned to a light condition by permuted block randomisation with n=6 block size 20 min prior to treatment in a 1:1 ratio."
Allocation concealment (selection bias)	Low	"…participants were randomised for exposure from 23:00 hours to 07:00 hours to either a blue-enriched white light …"
Blinding of participants and personnel (performance bias)	Unclear	NR
Blinding of outcome assessment (detection bias)	Unclear	NR
Incomplete outcome data (attrition bias)	Unclear	NR
Selective reporting (reporting bias)	Low	All expected outcomes reported
Other potential sources of bias	Low	Not relevant

21) Smith 2007

Study ID No. # 23	
1. General information	
Title: Napping and nightshift work: Effects of a short nap on psychomotor vigilance and subjective sleepiness in health workers	
Surname of first author: Smith	Year of study publication: 2007

Citation: Smith, S. S., Kilby, S., Jorgensen, G., & Douglas, J. (2007). Napping and nightshift work: Effects of a short nap on psychomotor vigilance and subjective sleepiness in health workers. Sleep and Biological Rhythms, 5, 117-125. doi:10.1111/j.1479-8425.2007.00261.x	
Publication type: .....Journal Article ■	
Ethical approval obtained for study: Yes ■	
2. Study characteristics	
Methods	**Study design:** Randomized cross-over trial **Intervention setting:** Healthcare **Night work hours and shift system:** Blocks of night shifts (20:30-07:00) over 1-3 consecutive days **Follow-up period (intervention plus follow-up):** Minimum 16 days **(Washout period for cross-over trial):** Minimum of 1 week
Participants	**Inclusion criteria:** NR **Exclusion criteria:** NR **Number screened:** NR **Number eligible:** NR **Number included in this review:** 9 **Industry:** Healthcare (nursing and medical science) **Age in years (mean (range)):** 45.7 ± 13.2 **Sex:** Both **Country:** Australia **Study duration:** NR
Interventions	**Intervention:** Strategic nap **Shift-based timing:** Night (on-shift) - first night of (potential 3-night block) **Hours of intervention:** Between 02:00 and 03:00 **Dose/duration/frequency:** 30 minutes per exposure, 1 exposure per night for 1 night **Control/comparison intervention:** No-nap with no corresponding break
Outcomes	**Sleepiness on-shift:** ▪ Subjective: NR | **Sleep length off-shift:** ▪ Subjective: NR | **Sleep quality off-shift:** ▪ Subjective: NR

	▪ Objective: NR	▪ Objective: PSG	▪ Objective: PSG
Notes	**Funding sources:** The School of Psychology, The University of Queensland, and the Sleep Disorders Centre, The Prince Charles Hospital, Brisbane, Queensland		

3. Risk of bias

Bias	Judgement	Support for judgement
Random sequence generation (selection bias)	Low	"The experiment used a randomized, controlled, crossover design." "The order of the conditions was randomized ahead of the experiment - this was done using a random number generator function in Excel in blocks of 4 to counterbalance the order across participants (e.g. the order could have been 1100, 0011, 1010, 0101 in each block).The allocation sequence was known to one investigator (not at the hospital site and never meeting the participants)"
Allocation concealment (selection bias)	Low	"The allocations were put in sealed and numbered envelopes, in a box kept at the study site. Another investigator (at the hospital site and conducting the study) opened the envelope on the day prior to each participant's first condition"
Blinding of participants and personnel (performance bias)	Low	"Participants were unaware of which condition (Nap or No-nap) that they were undergoing until the night of testing."
Blinding of outcome assessment (detection bias)	Unclear	NR
Incomplete outcome data (attrition bias)	Unclear	Numbers screened and eligible not reported
Selective reporting (reporting bias)	Low	All expected outcomes reported
Other potential sources of bias	Low	"The order of the conditions was randomized, and counterbalanced across participants"

22) Smith-Coggins 2006

Study ID No. # 21	
1. General information	
Title: Improving alertness and performance in emergency department physicians and nurses: the use of planned naps	
Surname of first author: Smith-Coggins	Year of study publication: 2006
Citation: Smith-Coggins, R., Howard, S. K., Mac, D. T., Wang, C., Kwan, S., Rosekind, M. R., . . . Gaba, D. M. (2006). Improving alertness and performance in emergency department physicians and nurses: the use of planned naps. Ann Emerg Med, 48(5), 596-604, 604 e591-593. doi:10.1016/j.annemergmed.2006.02.005	
Publication type: .....Journal Article ■	
Ethical approval obtained for study: Unclear ■	
2. Study characteristics	
Methods	**Study design:** Randomized controlled trial **Intervention setting:** Healthcare **Night work hours and shift system:** 3 consecutive 12-hour night shifts **Follow-up period (intervention plus follow-up):** 11 days
Participants	**Inclusion criteria:** Resident physicians and nurses working at least 3 consecutive 12-hour night shifts in the emergency department **Exclusion criteria:** NR **Number screened:** NR **Number eligible:** 53 **Number included in this review:** 49 **Industry:** Healthcare **Age in years (mean (range)):** 30 ± 5.5 (intervention); 30 ± 4.3 (control) **Sex:** Both **Country:** USA **Study duration:** June 2001 to June 2002

<table>
<tr><td>Interventions</td><td colspan="3">Intervention: Strategic naps
Shift-based timing: Night (on-shift)
Hours of intervention: Between 03:00 and 04:00
Dose/duration/frequency: 40-minute exposure, 1 exposure per night for 1 night
Control/comparison intervention: No-nap</td></tr>
<tr><td>Outcomes</td><td>Sleepiness on-shift:
▪ Subjective: Karolinska Sleepiness Scale (3 measurements per shift: pre, mid, and post); Profile of Mood States (category: fatigue/vigor): (3 measurements per shift: pre, mid, and post); Sleep diary (daily)
▪ Objective: NR</td><td>Sleep length off-shift:
▪ Subjective: NR
▪ Objective: Actigraphy (measurements made Day -5 to Day 5, with Day 3 being the randomized night</td><td>Sleep quality off-shift: NR</td></tr>
<tr><td>Notes</td><td colspan="3">Funding sources: No funding received</td></tr>
</table>

3. Risk of bias		
Bias	**Judgement**	**Support for judgement**
Random sequence generation (selection bias)	Low	…subjects were randomized into “nap” or “no-nap” groups, using a 50:50 randomization allocation ratio
Allocation concealment (selection bias)	Low	Investigators created sealed envelopes containing concealed assignment codes given sequentially to eligible subjects by a research associate
Blinding of participants and personnel (performance bias)	Unclear	Subjects and researchers were blinded as to group assignment until 11 p.m. of night 3
Blinding of outcome assessment (detection bias)	Unclear	Polysomnographic data were analyzed by an experienced technologist blinded to the protocol, but for remainder of outcomes, no information
Incomplete outcome data (attrition bias)	Low	“Figure E1: N = 53 eligible - 4 who withdrew” n = 49 randomized; n = 26 nap; n = 23 no-nap; n = 0 lost to follow-up; n = 0 excluded from analysis

Selective reporting (reporting bias)	Low	All expected outcomes reported
Other potential sources of bias	Low	Not relevant

23) Smith-Coggins 1997

Study ID No. # 22	
1. General information	
Title: Rotating shiftwork schedules: can we enhance physician adaptation to night shifts?	
Surname of first author: Smith-Coggins	Year of study publication: 1997
Citation: Smith-Coggins, R., Rosekind, M. R., Buccino, K. R., Dinges, D. F., & Moser, R. P. (1997). Rotating shiftwork schedules: can we enhance physician adaptation to night shifts? Acad Emerg Med, 4(10), 951-961.	
Publication type: .....Journal Article ■	
Ethical approval obtained for study: Unclear ■	
2. Study characteristics	
Methods	**Study design:** Randomized cross-over trial **Intervention setting:** Healthcare **Night work hours and shift system:** "Each subject had 10-16 8- or 9-hour shifts per month with 4-5 of those being night shifts." **Follow-up period (intervention plus follow-up):** between baseline data collection and experiment begin: not reported; 1-month experimental intervention and 1-month placebo control **(Washout period for cross-over trial):** 1 month
Participants	**Inclusion criteria:** NR **Exclusion criteria:** NR **Number screened:** NR **Number eligible:** 8

<table>
<tr><td></td><td colspan="3">Number included in this review: 6
Industry: Healthcare (physician)
Age in years (mean (range)): 34 ± 2.0
Sex: Male only
Country: USA
Study duration: NR</td></tr>
<tr><td>Interventions</td><td colspan="3">Intervention: Exposure to a 3-component fatigue countermeasure programme: (1) educational session with information on sleep physiology, circadian rhythms, good sleep hygiene, chonobiologic principles of scheduling; (2) improved shift schedule design*; and (3) 31 countermeasure strategies to maintain alertness and performance during work
Shift-based timing: NR
Hours of intervention: NR
Dose/duration/frequency: 2-hour education session
Control/comparison intervention: “Jet lag diet” (considered active placebo); 2-hour general information on normal sleep physiology and circadian rhythms</td></tr>
<tr><td>Outcomes</td><td>Sleepiness on-shift:
▪ Subjective: NR
▪ Objective: NR</td><td>Sleep length off-shift:
▪ Subjective: sleep/wake diary one week before and one week after each testing period
▪ Objective: polysomnographic records on all 6 testing days</td><td>Sleep quality off-shift:
▪ Subjective: sleep/wake diary one week before and one week after each testing period
▪ Objective: polysomnographic records on all 6 testing days</td></tr>
<tr><td>Notes</td><td colspan="3">Funding sources: Emergency Medicine Foundation, the Society for Academic Emergency Medicine,NIHGrantMH44193 and the Institute for Experimental Psychiatry Research Foundation</td></tr>
</table>

3. Risk of bias

Bias	Judgement	Support for judgement
Random sequence generation (selection bias)	Unclear	NR
Allocation concealment (selection bias)	Unclear	NR
Blinding of participants and personnel (performance bias)	Low	“The subjects were blinded to the fact that the diet was an active placebo.” “...performance tests done by persons blinded to group”

Blinding of outcome assessment (detection bias)	Low	Double-blind
Incomplete outcome data (attrition bias)	Unclear	“Polysomnographic data: Due to a technical problem, 25% of the baseline polysomnographic data were lost. Analysis was completed with the remaining baseline data and complete post-intervention data”
Selective reporting (reporting bias)	Low	All expected outcomes reported
Other potential sources of bias	High	“The question of order effect was addressed by the use of counterbalancing in the within-subjects design” “Since the subjects had been in medicine for a decade, they had learned many of the suggested countermeasures by trial and error and had already incorporated these principles into their daily habits. It may have been difficult for the subjects to give up the strategies during the active placebo and this may have decreased the difference between the 2 conditions”

24) Sullivan 2017

Study ID No. # 24	
1. General information	
Title: Randomized, Prospective Study of the Impact of a Sleep Health Program on Firefighter Injury and Disability	
Surname of first author: Sullivan	Year of study publication: 2017
Citation: Sullivan, J. P., O'Brien, C. S., Barger, L. K., Rajaratnam, S. M., Czeisler, C. A., Lockley, S. W., . . . Safety, G. (2017). Randomized, Prospective Study of the Impact of a Sleep Health Program on Firefighter Injury and Disability. Sleep, 40(1). doi:10.1093/sleep/zsw001	
Publication type: .....Journal Article ■	
Ethical approval obtained for study: Yes ■	
2. Study characteristics	

<table>
<tr><td>Methods</td><td colspan="3">Study design: Randomized controlled trial
Intervention setting: Fire department
Night work hours and shift system: “…routinely scheduled to work 24-hour shifts in a recurring sequence of 24 hours on duty, followed by 48-hours off duty.” Night work hours include 23:00—07:00 hours
Follow-up period (intervention plus follow-up): 4 years</td></tr>
<tr><td>Participants</td><td colspan="3">Inclusion criteria: “Any firefighter present at the station was permitted to attend.”
Exclusion criteria: NR
Number screened: 75 fire departments
Number eligible: 75 fire departments, 1,211 firefighters
Number included in this review: 32 departments, 1,189 firefighters
Industry: Fire department (firefighters)
Age in years (mean (range)): 43.6 ± 7.4 (22–72)
Sex: Both
Country: USA
Study duration: mid-August 2009—August 2013</td></tr>
<tr><td>Interventions</td><td colspan="3">Intervention: Sleep health program that include: (1) Mandatory Educational Sessions, (2) Voluntary Sleep Disorders Screening, and (3) Sleep Disorders Diagnosis and Treatment for those who screened at risk for a sleep disorder.
Shift-based timing: Not relevant
Hours of intervention: Not relevant
Dose/duration/frequency: Single 30-minute face-to-face lecture
Control/comparison intervention: No-sleep health program</td></tr>
<tr><td>Outcomes</td><td>Sleepiness on-shift:
▪ Subjective: Athens Insomnia Scale (AIS)
▪ Objective: NR</td><td>Sleep length off-shift:
▪ Subjective: Athens Insomnia Scale (AIS
▪ Objective: NR</td><td>Sleep quality off-shift:
▪ Subjective: Athens Insomnia Scale (AIS)
▪ Objective: NR</td></tr>
<tr><td>Notes</td><td colspan="3">Funding sources: Federal Emergency Management Agency (FEMA) Assistance for Firefighters grants; National Institute of Occupational Safety and Health grant; National Institutes of Health National Heart, Lung, and Blood Institute grant</td></tr>
<tr><td colspan="4">3. Risk of bias</td></tr>
</table>

Bias	Judgement	Support for judgement
Random sequence generation (selection bias)	Unclear	NR

Allocation concealment (selection bias)	Low	"One station from each pair was then randomly selected to receive the SHP by the investigators."
Blinding of participants and personnel (performance bias)	Unclear	"Although randomized, a double-blind design was not possible in this field study; however, as the outcomes were derived from standard departmental records rather than study participants, we believe it unlikely that knowledge of group assignment influenced the incidence of long-term disability between the groups."
Blinding of outcome assessment (detection bias)	Unclear	NR
Incomplete outcome data (attrition bias)	Unclear	"…the low response rate to the end-of-year survey which reduced our power to detect changes in self-reported sleep and behavior in those who participated in the program. Given that none of these outcomes were significant, however, any bias due to the low numbers may have resulted in underestimating the impact of the program."
Selective reporting (reporting bias)	Low	All expected outcomes reported
Other potential sources of bias	Low	Not relevant

25) Tanaka 2011

Study ID No. # 25	
1. General information	
Title: Brief morning exposure to bright light improves subjective symptoms and performance in nurses with rapidly rotating shifts	
Surname of first author: Tanaka	Year of study publication: 2011
Citation: Tanaka, K., Takahashi, M., Tanaka, M., Takanao, T., Nishinoue, N., Kaku, A., . . . Miyaoka, H. (2011). Brief morning exposure to bright light improves subjective symptoms and performance in nurses with rapidly rotating shifts. J Occup Health, 53(4), 258-266.	
Publication type: .....Journal Article ■	

Ethical approval obtained for study: Yes ■			
2. Study characteristics			
Methods	**Study design:** Randomized cross-over trial **Intervention setting:** Healthcare **Night work hours and shift system:** Rapidly rotating cycle **Follow-up period (intervention plus follow-up):** 2 months plus one week **(Washout period for cross-over trial):** 1 week		
Participants	**Inclusion criteria:** Age 20-60 yrs; working a two-shift system **Exclusion criteria:** Individuals with sensitivity to bright light, eye disorders including asthenopia or who reported headaches or mood disorders; senior nursing officers **Number screened:** 276 **Number eligible:** NR **Number included in this review:** 61 **Industry:** Healthcare (Nursing) **Age in years (mean (range)):** 29.7± 8.6 **Sex:** Female only **Country:** Japan **Study duration:** Beginning of June to beginning of August 2006		
Interventions	**Intervention:** Exposure to bright light via a light box **Shift-based timing:** Day (on-shift) **Hours of intervention:** 07:30-08:00 **Dose/duration/frequency:** 5444-8826 lux (with illumination at 40-30 cm from the light source), 10minutes per exposure, 1 exposure each day-shift workday for one month **Control/comparison intervention:** Normal light (530 and 648 lux, based on measured values in a windowless nurses' station room)		
Outcomes	**Sleepiness on-shift:** ▪ Subjective: Karolinska Sleepiness Scale ▪ Objective: NR	**Sleep length off-shift:** ▪ Subjective: Sleep diary ▪ Objective: NR	**Sleep quality off-shift:** ▪ Subjective: Sleep diary; VAS (the following morning) ▪ Objective: NR

Notes	**Funding sources:** Japan Society for the Promotion of Science	
3. Risk of bias		
Bias	**Judgement**	**Support for judgement**
Random sequence generation (selection bias)	Low	Random assignment was performed using a permuted block method with a block size of four. A random number sequence was generated by a computer. A research assistant with no direct contact with participants was responsible for generating the random numbers
Allocation concealment (selection bias)	Unclear	NR
Blinding of participants and personnel (performance bias)	High	"open-label trials involve potential biases resulting from difference in management, intervention, or assessment of participants that may arise due to participants or investigators knowing about the assigned intervention"
Blinding of outcome assessment (detection bias)	Low	"Evaluators were masked to allocation"
Incomplete outcome data (attrition bias)	Low	"The PVT values were excluded from the analysis…"
Selective reporting (reporting bias)	Unclear	All outcomes reported except for sleep diary outcomes.
Other potential sources of bias	Low	"No significant main effect of order or interaction between BL and order were found for any items"

26) Thorne 2010

Study ID No. # 26	
1. General information	
Title: Returning from night shift to day life: Beneficial effects of light on sleep	
Surname of first author: Thorne	Year of study publication: 2010
Citation: Thorne, H. C., Hampton, S. M., Morgan, L. M., Skene, D. J., & Arendt, J. (2010). Returning from night shift to day life: Beneficial effects of light on sleep. Sleep and Biological Rhythms, 8(1), 212-221. doi:10.1111/j.1479-8425.2010.00451.x	

Publication type: .....Journal Article ■			
Ethical approval obtained for study: Yes ■			
2. Study characteristics			
Methods	**Study design:** Randomized cross-over trial **Intervention setting:** Onshore at home following offshore oilrig platform work **Night work hours and shift system:** Two weeks of night shift, followed by two weeks at home, two weeks of day shift, followed by two weeks at home. Repeat **Follow-up period (intervention plus follow-up):** 21 days (last 7 days of a 2- or 3-week night-shift schedule, 14 days at home after completion of the night shift) **(Washout period for cross-over trial):** 6-8 weeks		
Participants	**Inclusion criteria:** Working a 2-3-week night shift **Exclusion criteria:** On any medication known to affect the melatonin rhythm (b-blockers, a-blockers, calcium channel blockers, antipsychotics, benzodiazepines, antidepressants, barbiturates, and antiepileptic drugs) **Number screened:** NR **Number eligible:** 10 **Number included in this review:** 10 **Industry:** Offshore oil rig **Age in years (mean (range)):** 46 ± 11 years **Sex:** Male only **Country:** UK **Study duration:** May-August		
Interventions	**Intervention:** Light: exposure to white polychromatic light via a light box **Shift-based timing:** Day (off-shift) **Hours of intervention:** Treatment 1 (T1): 13:00; T2: 12:00; T3: 11:00; T4: 10:00 **Dose/duration/frequency:** Light: 3000 lux, 60 minutes per exposure, 1 exposure per day **Control/comparison intervention:** No bright light, no sunglasses		
Outcomes	**Sleepiness on-shift:** NR	**Sleep length off-shift:** ▪ Subjective: Sleep diary; daily ▪ Objective: Actigraphy, 21 days	**Sleep quality off-shift:** ▪ Subjective: Sleep diary; daily ▪ Objective: Actigraphy, 21 days

Notes	**Funding sources:** Japan Society for the Promotion of Science	
3. Risk of bias		
Bias	**Judgement**	**Support for judgement**
Random sequence generation (selection bias)	Unclear	NR
Allocation concealment (selection bias)	Unclear	NR
Blinding of participants and personnel (performance bias)	High	"Subject motivation may also be very important given that it is virtually impossible to blind such light experiments. "
Blinding of outcome assessment (detection bias)	Unclear	NR
Incomplete outcome data (attrition bias)	Unclear	No actigraphy data obtained (n = 1).
Selective reporting (reporting bias)	Low	All expected outcomes reported
Other potential sources of bias	Low	Adequate washout period of 6-8 weeks

27) Viitasalo 2008

Study ID No. # 27	
1. General information	
Title: Effects of shift rotation and the flexibility of a shift system on daytime alertness and cardiovascular risk factors.	
Surname of first author: Viitasalo	Year of study publication: 2008

Citation: Viitasalo, K., Kuosma, E., Laitinen, J., & Harma, M. (2008). Effects of shift rotation and the flexibility of a shift system on daytime alertness and cardiovascular risk factors. Scand J Work Environ Health, 34(3), 198-205.			
Publication type: .....Journal Article ■			
Ethical approval obtained for study: Yes ■			
2. Study characteristics			
Methods	**Study design:** Randomized controlled trial **Intervention setting:** Airline company **Night work hours and shift system:** **Follow-up period (intervention plus follow-up):** 1 year		
Participants	**Inclusion criteria:** employees responsible for small and medium-sized maintenance duties and following 8-hour backward rotating shift schedules. "The order of the shifts in the old schedule was EEE -- MMM -- NNN -- (E = evening shift, M = morning shift, N = night shift, - = day off). The shift changing times were at 0700, 1500, and 2300, and all of the shifts were 8 hours long." **Exclusion criteria:** NR **Number screened:** 343 **Number eligible:** 84 **Number included in this review:** 84 **Industry:** Airline company (maintenance personnel) **Age in years (mean (range)):** 27-58 **Sex:** Male only **Country:** Finland **Study duration:** October 2004—December 2005		
Interventions	**Intervention:** shift schedule modification (direction and speed) **Shift-based timing:** NR **Hours of intervention:** Not relevant **Dose/duration/frequency:** For 1-year period **Control/comparison intervention:** continuous backward-rotating three-shift system		
Outcomes	**Sleepiness on-shift:**	**Sleep length off-shift:** NR	**Sleep quality off-shift:** NR

	▪ Subjective: Basic Nordic Sleep Questionnaire (BNSQ); Epworth Sleepiness Scale (ESS) ▪ Objective: NR		
Notes	**Funding sources:** The Mutual Pension Insurance Company Ilmarinen		

3. Risk of bias		
Bias	**Judgement**	**Support for judgement**
Random sequence generation (selection bias)	Unclear	NR
Allocation concealment (selection bias)	High	"The employer and the representatives of the employees wanted the workers to self-select their new shift systems, and it was therefore not possible to randomize the allocation of the participants into the study groups." "…we could not randomize the allocation of the participants into the study groups…"
Blinding of participants and personnel (performance bias)	Unclear	NR
Blinding of outcome assessment (detection bias)	Unclear	NR
Incomplete outcome data (attrition bias)	High	"…one participant died accidentally, one changed to fixed night work, one could not take part in the follow-up survey because of sick leave due to a leisure-time injury, and two were on a leave of several months at the follow-up time…"
Selective reporting (reporting bias)	Low	All expected outcomes reported
Other potential sources of bias	Low	Adequate follow-up period

28) Zion 2019

Study ID No. # 28	
1. General information	
Title: Let them sleep: The effects of a scheduled nap during the night shift on sleepiness and cognition in hospital nurses.	
Surname of first author: Zion	Year of study publication: 2019
Citation: Zion, N., & Shochat, T. (2019). Let them sleep: The effects of a scheduled nap during the night shift on sleepiness and cognition in hospital nurses. Journal of Advanced Nursing. doi:10.1111/jan.14031.	
Publication type: .....Journal Article ■	
Ethical approval obtained for study: Yes ■	
2. Study characteristics	
Methods	**Study design:** Randomized cross-over trial **Intervention setting:** Healthcare **Night work hours and shift system:** 8-hour night shift (23:00-7:00) **Follow-up period (intervention plus follow-up):** 4 nights **(Washout period for cross-over trial):** NR
Participants	**Inclusion criteria:** working at least 75% of full time (28 hours per week) and at least one night shift per week; working irregular rotating shifts including night shifts were recruited. **Exclusion criteria:** conditions that may affect sleep and/or function, including a diagnosed sleep disorder, a chronic medical condition, or pregnancy. **Number screened:** 119 **Number eligible:** 110 **Number included in this review:** 110 **Industry:** Healthcare (nursing) **Age in years (mean (range)):** 23-63 **Sex:** Female only **Country:** Israel

	Study duration: August 2011 and April 2014.		
Interventions	**Intervention:** Strategic naps **Shift-based timing:** NR **Hours of intervention:** Night (on-shift) **Dose/duration/frequency:** participants were instructed to retire to a dark and quiet room for 40 minutes at 4:00 a.m.; approximately 30-minute nap and an additional 10 minutes both to settle down before and to recover after the nap. **Control/comparison intervention:** no-nap		
Outcomes	**Sleepiness on-shift:** ▪ Subjective: KSS ▪ Objective: NR	**Sleep length off-shift:** ▪ Subjective: Pittsburgh Sleep Quality Index (PSQI), ▪ Objective: Actigraphy	**Sleep quality off-shift:** ▪ Subjective: PSQI, Pre-Sleep Arousal Scale (PSAS) ▪ Objective: Actigraphy
Notes	**Funding sources:** Israel Ministry of Economy and Industry		

3. Risk of bias		
Bias	**Judgement**	**Support for judgement**
Random sequence generation (selection bias)	Low	"To minimize the effect of order, participants were randomly assigned to five order groups: (1) nap/no-nap/nap/no-nap, (2) no-nap/nap/no-nap/nap, (3) nap/no-nap/no-nap/nap, (4) no-nap/nap/nap/no-nap and (5) no-nap/no-nap/nap/nap."
Allocation concealment (selection bias)	Unclear	NR
Blinding of participants and personnel (performance bias)	Unclear	NR
Blinding of outcome assessment (detection bias)	Unclear	NR
Incomplete outcome data (attrition bias)	Low	Participants completed all experimental conditions
Selective reporting (reporting bias)	Low	All expected outcomes reported
Other potential sources of bias	Low	Not relevant

Appendix 7 Authors' conclusions for included studies

No.	Study	Intervention	Author's conclusion	Effect of intervention on sleep
1	Bjorvatn 2007	Controlled light exposure	"In general, the effects were modest, especially for the night work period…bright light improved sleep to a minor degree. Due to the multiple statistical tests, one may argue that the data indicate that bright light and melatonin were relatively ineffective for adaptation to night work in this real life setting."	–
2	Chang 2015	Strategic nap	"In the results, we found there were no differences in the subjective sleepiness among the three groups working the daytime, night shift without a nap and with a nap." "…the night shift groups experienced an approximate 2-h reduction in sleep length compared to the daytime shift group, there was no difference in subjective sleepiness among the groups."	–
3	Chang 2017	Aromatherapy	"…our study found that aromatherapy massage is an effective treatment in improving sleep quality (PSQI score and subjective sleep quality) of the nurses on monthly rotating night shifts. We found that the total PSQI was significantly decreased in the treatment group following the aromatherapy massage. Specifically, the components such as subjective sleep quality, sleep disturbance, and daytime dysfunction were significantly decreased."	+
4	Griepentrog 2018	Controlled bright light exposure	"…we observed that prolonged exposure to high-intensity lighting during the night reduced post-shift subjective sleepiness among ICU nurses but resulted in more errors."	+
5	Harma 2006	Shift schedule modification	"…although the new shift system increased the operating hours at night, the very rapidly forward rotating shift system had positive effects on the sleep, alertness and well-being of especially the older shift workers"	+
6	Howard 2010	Strategic nap	"A brief napping opportunity at any stage during the shift was not sufficient to overcome sleep deprivation and circadian effects on performance at the end of the shift."	–
7	Huang 2013	Controlled light exposure	"…bright light therapy of 7,000-10,000 lux for at least 30 minutes at night for at least 10 days during 2 weeks significantly improved the sleep problems of nurses working the evening or night shift."	+

8	Jarnefelt 2012	Behavioral training	"…group-based CBT-I partly improved shift workers' sleep. The participants generally slept better on days off than on work days and the treatment equally improved sleep on both types of days. The effects lasted, and partly improved during the follow-ups up to 60months."	+
9	Karchani 2011	Controlled light exposure	"Our study showed the positive effect of bright light in reducing the degree of subjective sleepiness, which supports the use of light for better conformity with night-working"	+
10	Kim 2016	Aromatherapy	"The findings show that the inhalation of aroma essential oil had effects to increase the quality of sleep and to decrease the number of awakenings after sleep onset."	+
11	Lee 2014	Behavioral training	"After the SETS-SW intervention, participants reported better sleep quality, although no change in actigraphy outcomes was observed. The SETS-SW intervention had its most encouraging effect on the nurses' perceptions of their sleep, with moderate to strong effect sizes on both the PSQI and GSDS. Following the SETS-SW intervention, participants reported better sleep quality, less difficulty falling asleep, and fewer problems with early awakening. A reduction in the use of sleep aids had an effect size in the moderate range, but did not reach statistical significance. Sleep improvements were reported both between night shifts and on days off work."	+
12	Lowden 2004	Controlled light exposure	"Total sleep time was positively affected by light exposure. However, neither sleep efficiency nor the wake diary gave any indications of an improvement of quality of sleep."	+
13	Oriyama 2014	Strategic nap	"Although napping for 15 min at 2:30 and during the period from 4:30 to 5:45 during the night shift was not shown to decrease subjective sleepiness or fatigue…"	–
14	Pykkonen 2018	Behavioral training	"The current study failed to provide clear evidence for a feasible alertness management training being beneficial in improving long-haul truck drivers' on-duty alertness, amount of prior sleep, and use of efficient on-duty sleepiness counter measurements, while working early morning and night shifts."	–
15	Rahman 2013	Short-wavelength light protection	"…under intervention, total sleep time was increased by a mean of 40 min compared with baseline, wake after sleep onset was reduced and sleep efficiency was increased to levels similar to the comparator night… filtering short wavelengths may be an	+

			approach to reduce sleep disruption and improve performance in rotating-shift workers"	
16	Ross 1995	Controlled light exposure	"The bright white light group showed markedly improved sleep latency in the second and third weeks after night-shift compared to dim red light treatment. As well as using bright light to enhance nightshift adaptation, it might well be beneficial for employers to arrange for workers to receive exposure to appropriately timed bright, artificial or natural light in the days after a night-shift in suitable circumstances."	+
17	Sadeghniat-Haghighi 2011	Controlled light exposure	"This study demonstrates the effectiveness of exposure to bright light on decreasing the level of sleepiness among shift workers during their breaks. Despite the short duration of exposure to bright light (two 20-minute breaks), significant effects was observed."	+
18	Sallinen 1998	Strategic nap	"Subjective sleepiness was less clearly decreased by the naps as compared with the lapse measured of the repeated task test."	–
19	Scott 2010	Behavioral training	"… significant improvements were noted in sleep duration, sleep quality, and alertness. Although significant improvements were not found in daytime sleepiness scores, the severity of daytime sleepiness appeared to decrease."	+
20	Sletten 2017	Controlled light exposure	"Sleepiness and neurobehavioural performance during the night shift were not significantly improved by blue-enriched, as compared with standard, light."	–
21	Smith 2007	Strategic nap	"The present results show that a single brief nap in the workplace between 02:00 and 03:00 hours had a positive effect of subjective sleepiness."	+
22	Smith-Coggins 1997	Behavioral training	"Although the experimental intervention was successfully implemented, it failed to significantly improve attending physicians' sleep, performance, or mood on night shifts."	–
23	Smith-Coggins 2006	Strategic nap	"Results showed that a 40-minute nap opportunity allowed health care professionals to maintain their performance, self-reported alertness, and mood through the end of their night shift."	+
24	Sullivan 2017	Behavioral training	"There were no significant changes pre- versus post-study in self-reported sleep or sleepiness in those who participated in the intervention."	–
25	Tanaka 2011	Controlled light exposure	"…we found that short-term exposure to BL…significantly improved self-assessed sleepiness…"	+

26	Thorne 2010	Controlled light exposure	“The results of this study are that light treatment has varying effects on the sleep of offshore shift workers. During the first 5 days after the night shift, significant differences were only observed in actigraphyic sleep efficiency, which was substantially improved by light treatment (79% compared to 87%). During days 6–14 (after the light exposure period) measurements of actigraphyic sleep showed there was a significant improvement in sleep duration, though unexpectedly a decrease in sleep quality in the light treatment leg compared to the no light treatment leg.”	+
27	Vitiasalo 2008	Shift schedule modification	“In our study, the change from a slower backward-rotating shift system (shift changes every three shifts) to a very quickly forward-rotating shift schedule improved the perceived alertness of the workers, even though the operating hours at night actually increased.”	+
28	Zion 2019	Strategic nap	“The authors found lower sleepiness and modestly improved cognitive performance following the nap versus the no-nap condition.”	+

Appendix 8 List of the included studies

No	Study
1	Bjorvatn, B., Stangenes, K., Oyane, N., Forberg, K., Lowden, A., Holsten, F., & Akerstedt, T. (2007). Randomized placebo-controlled field study of the effects of bright light and melatonin in adaptation to night work. Scand J Work Environ Health, 33(3), 204-214.
2	Chang, Y. S., Wu, Y. H., Lu, M. R., Hsu, C. Y., Liu, C. K., & Hsu, C. (2015). Did a brief nap break have positive benefits on information processing among nurses working on the first 8-h night shift? Appl Ergon, 48, 104-108. doi:10.1016/j.apergo.2014.11.005
3	Chang, Y. Y., Lin, C. L., & Chang, L. Y. (2017). The Effects of Aromatherapy Massage on Sleep Quality of Nurses on Monthly Rotating Night Shifts. Evid Based Complement Alternat Med, 2017, 3861273. doi:10.1155/2017/3861273
4	Griepentrog, J. E., Labiner, H. E., Gunn, S. R., & Rosengart, M. R. (2018). Bright environmental light improves the sleepiness of nightshift ICU nurses. Critical Care, 22(1), 295-304. doi:10.1186/s13054-018-2233-4
5	Harma, M., Tarja, H., Irja, K., Mikael, S., Jussi, V., Anne, B., & Pertti, M. (2006). A controlled intervention study on the effects of a very rapidly forward rotating shift system on sleep-wakefulness and well-being among young and elderly shift workers. Int J Psychophysiol, 59(1), 70-79. doi:10.1016/j.ijpsycho.2005.08.005
6	Howard, M. E., Radford, L., Jackson, M. L., Swann, P., & Kennedy, G. A. (2010). The effects of a 30-minute napping opportunity during an actual night shift on performance and sleepiness in shift workers. Biological Rhythm Research, 41(2), 137-148. doi:10.1080/09291010903030946
7	Huang, L. B., Tsai, M. C., Chen, C. Y., & Hsu, S. C. (2013). The effectiveness of light/dark exposure to treat insomnia in female nurses undertaking shift work during the evening/night shift. J Clin Sleep Med, 9(7), 641-646. doi:10.5664/jcsm.2824
8	Jarnefelt, H., Lagerstedt, R., Kajaste, S., Sallinen, M., Savolainen, A., & Hublin, C. (2012). Cognitive behavior therapy for chronic insomnia in occupational health services. J Occup Rehabil, 22(4), 511-521. doi:10.1007/s10926-012-9365-1
9	Karchani, M., Kakooei, H., Yazdi, Z., & Zare, M. (2011). Do bright-light shock exposures during breaks reduce subjective sleepiness in night workers? Sleep and Biological Rhythms, 9, 95-102. doi:10.1111/j.1479-8425.2011.00490.x
10	Kim, W., & Hur, M. H. (2016). Inhalation Effects of Aroma Essential Oil on Quality of Sleep for Shift Nurses after Night Work. J Korean Acad Nurs, 46(6), 769-779. doi:10.4040/jkan.2016.46.6.769
11	Lee, K. A., Gay, C. L., & Alsten, C. R. (2014). Home-based behavioral sleep training for shift workers: a pilot study. Behav Sleep Med, 12(6), 455-468. doi:10.1080/15402002.2013.825840
12	Lowden, A., Akerstedt, T., & Wibom, R. (2004). Suppression of sleepiness and melatonin by bright light exposure during breaks in night work. J Sleep Res, 13(1), 37-43.
13	Oriyama, S., Miyakoshi, Y., & Kobayashi, T. (2014). Effects of two 15-min naps on the subjective sleepiness, fatigue and heart rate variability of night shift nurses. Ind Health, 52(1), 25-35.
14	Pylkkonen, M., Tolvanen, A., Hublin, C., Kaartinen, J., Karhula, K., Puttonen, S., . . . Sallinen, M. (2018). Effects of alertness management training on

	sleepiness among long-haul truck drivers: A randomized controlled trial. Accid Anal Prev, 121, 301-313. doi:10.1016/j.aap.2018.05.008
15	Rahman, S. A., Shapiro, C. M., Wang, F., Ainlay, H., Kazmi, S., Brown, T. J., & Casper, R. F. (2013). Effects of filtering visual short wavelengths during nocturnal shiftwork on sleep and performance. Chronobiol Int, 30(8), 951-962. doi:10.3109/07420528.2013.789894
16	Ross, J. K., Arendt, J., Horne, J., & Haston, W. (1995). Night-shift work in Antarctica: sleep characteristics and bright light treatment. Physiol Behav, 57(6), 1169-1174.
17	Sadeghniiat-Haghighi, K., Yazdi, Z., Jahanihashemi, H., & Aminian, O. (2011). The effect of bright light on sleepiness among rapid-rotating 12-hour shift workers. Scand J Work Environ Health, 37(1), 77-79.
18	Sallinen, M., Harma, M., Akerstedt, T., Rosa, R., & Lillqvist, O. (1998). Promoting alertness with a short nap during a night shift. J Sleep Res, 7(4), 240-247.
19	Scott, L. D., Hofmeister, N., Rogness, N., & Rogers, A. E. (2010). An interventional approach for patient and nurse safety: a fatigue countermeasures feasibility study. Nurs Res, 59(4), 250-258. doi:10.1097/NNR.0b013e3181de9116
20	Sletten, T. L., Ftouni, S., Nicholas, C. L., Magee, M., Grunstein, R. R., Ferguson, S., . . . Rajaratnam, S. M. W. (2017). Randomised controlled trial of the efficacy of a blue-enriched light intervention to improve alertness and performance in night shift workers. Occup Environ Med, 74(11), 792-801. doi:10.1136/oemed-2016-103818
21	Smith, S. S., Kilby, S., Jorgensen, G., & Douglas, J. (2007). Napping and nightshift work: Effects of a short nap on psychomotor vigilance and subjective sleepiness in health workers. Sleep and Biological Rhythms, 5, 117-125. doi:10.1111/j.1479-8425.2007.00261.x
22	Smith-Coggins, R., Howard, S. K., Mac, D. T., Wang, C., Kwan, S., Rosekind, M. R., . . . Gaba, D. M. (2006). Improving alertness and performance in emergency department physicians and nurses: the use of planned naps. Ann Emerg Med, 48(5), 596-604, 604 e591-593. doi:10.1016/j.annemergmed.2006.02.005
23	Smith-Coggins, R., Rosekind, M. R., Buccino, K. R., Dinges, D. F., & Moser, R. P. (1997). Rotating shiftwork schedules: can we enhance physician adaptation to night shifts? Acad Emerg Med, 4(10), 951-961.
24	Sullivan, J. P., O'Brien, C. S., Barger, L. K., Rajaratnam, S. M., Czeisler, C. A., Lockley, S. W., . . . Safety, G. (2017). Randomized, Prospective Study of the Impact of a Sleep Health Program on Firefighter Injury and Disability. Sleep, 40(1). doi:10.1093/sleep/zsw001
25	Tanaka, K., Takahashi, M., Tanaka, M., Takanao, T., Nishinoue, N., Kaku, A., . . . Miyaoka, H. (2011). Brief morning exposure to bright light improves subjective symptoms and performance in nurses with rapidly rotating shifts. J Occup Health, 53(4), 258-266.
26	Thorne, H. C., Hampton, S. M., Morgan, L. M., Skene, D. J., & Arendt, J. (2010). Returning from night shift to day life: Beneficial effects of light on sleep. Sleep and Biological Rhythms, 8(1), 212-221. doi:10.1111/j.1479-8425.2010.00451.x
27	Viitasalo, K., Kuosma, E., Laitinen, J., & Harma, M. (2008). Effects of shift rotation and the flexibility of a shift system on daytime alertness and cardiovascular risk factors. Scand J Work Environ Health, 34(3), 198-205.
28	Zion, N., & Shochat, T. (2019). Let them sleep: The effects of a scheduled nap during the night shift on sleepiness and cognition in hospital nurses. Journal of Advanced Nursing. doi:10.1111/jan.14031.

Note. Studies are listed in an alphabetical order.

Appendix 9 List of the excluded studies with reasons

Reasons for exclusion:

(1) No population of interest: studies did not involve workers engaged in night work positions as the focus population; did not clearly state the inclusion of night workers

(2) No intervention of interest: studies did not explore the effects of non-pharmacological strategies; did not clearly state the interventional methods

(3) No outcome of interest: studies did not explore and assess sleep as an outcome variable, did not clearly define the method of sleep assessment; did not clearly state and define what was considered as sleep disturbances; did not use validated sleep assessment method

(4) No study design of interest: studies had non-experimental design (e.g. observational studies, reviews, or correspondence letters)

(5) No access to the original full-text article despite rigorous search

(6) Ongoing work with inconclusive findings

No.	Study	Reason for exclusion
1	Ando, K., Kripke, D. F., Cole, R. J., & Elliott, J. A. (1999). Light mask 500 lux treatment for delayed sleep phase syndrome. Prog Neuropsychopharmacol Biol Psychiatry, 23(1), 15-24.	(1)
2	Arora, V., Dunphy, C., Chang, V. Y., Ahmad, F., Humphrey, H. J., & Meltzer, D. (2006). The effects of on-duty napping on intern sleep time and fatigue. *Ann Intern Med, 144*(11), 792-798.	(1)
3	Atlantis, E., Chow, C. M., Kirby, A., & Fiatarone Singh, M. A. (2006). Worksite intervention effects on physical health: a randomized controlled trial. *Health Promot Int, 21*(3), 191-200. doi:10.1093/heapro/dal012	(3)
4	Atlantis, E., Chow, C. M., Kirby, A., & Singh, M. A. F. (2006). Worksite intervention effects on sleep quality: a randomized	(5)

	controlled trial. *J Occup Health Psychol, 11*(4), 291-304. doi:10.1037/1076-8998.11.4.291	
5	Baek, H., & Min, B. K. (2015). Blue light aids in coping with the post-lunch dip: an EEG study. Ergonomics, 58(5), 803-810. doi:10.1080/00140139.2014.983300	(1)
6	Bambra, C. L., Whitehead, M. M., Sowden, A. J., Akers, J., & Petticrew, M. P. (2008). Shifting schedules: the health effects of reorganizing shift work. Am J Prev Med, 34(5), 427-434. doi:10.1016/j.amepre.2007.12.023	(4)
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109	Williamson, A. M., Gower, C. G., & Clarke, B. C. (1994). Changing the hours of shiftwork: a comparison of 8- and 12-hour shift rosters in a group of computer operators. Ergonomics, 37(2), 287-298. doi:10.1080/00140139408963646	(4)
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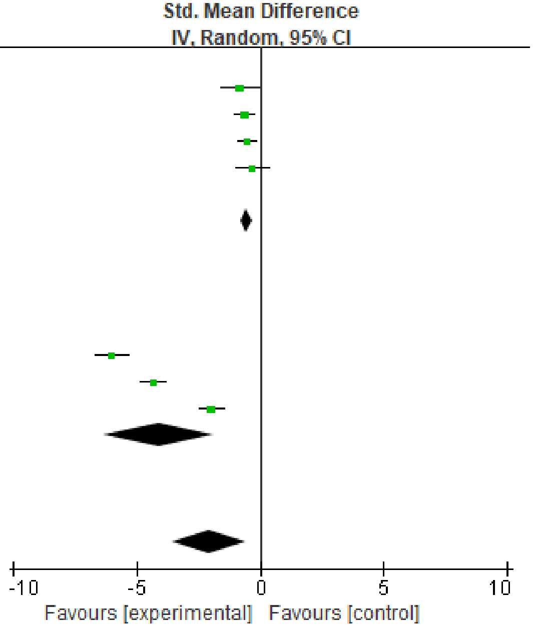
Note. Studies are listed in an alphabetical order.

Appendix 10 The effect of non-pharmacological interventions on sleepiness on-shift: sensitive analysis for KSS

	Experimental			Control				Std. Mean Difference
Study or Subgroup	Mean	SD	Total	Mean	SD	Total	Weight	IV, Random, 95% CI
1.1.1 Sleepiness on-shift: KSS								
Sallinen 1998	6.9	1.8	14	8.2	1.2	14	14.0%	-0.83 [-1.60, -0.05]
Smith-Coggins 2006	5.36	1.78	49	6.48	1.78	49	14.4%	-0.62 [-1.03, -0.22]
Tanaka 2011	3.74	1.01	61	4.29	1.01	61	14.5%	-0.54 [-0.90, -0.18]
Bjorvatn 2007	4	0.8	17	4.3	1	17	14.2%	-0.32 [-1.00, 0.35]
Zion 2019	3.6	0.16	110	4.89	0.16	110		Not estimable
Subtotal (95% CI)			**141**			**141**	**57.1%**	**-0.57 [-0.81, -0.33]**
Heterogeneity: Tau² = 0.00; Chi² = 1.02, df = 3 (P = 0.80); I² = 0%								
Test for overall effect: Z = 4.68 (P < 0.00001)								
1.1.2 Sleepiness on-shift: SSS								
Sadeghniiat-Haghighi 2011	2.43	0.12	94	3.07	0.09	94	14.2%	-6.01 [-6.69, -5.33]
Karchani 2011	2.02	0.58	90	4.8	0.69	90	14.3%	-4.34 [-4.88, -3.80]
Griepentrog 2018	2.6	0.2	43	3	0.2	43	14.3%	-1.98 [-2.50, -1.46]
Subtotal (95% CI)			**227**			**227**	**42.9%**	**-4.10 [-6.35, -1.86]**
Heterogeneity: Tau² = 3.85; Chi² = 91.70, df = 2 (P < 0.00001); I² = 98%								
Test for overall effect: Z = 3.58 (P = 0.0003)								
Total (95% CI)			**368**			**368**	**100.0%**	**-2.09 [-3.57, -0.61]**
Heterogeneity: Tau² = 3.92; Chi² = 336.06, df = 6 (P < 0.00001); I² = 98%								
Test for overall effect: Z = 2.76 (P = 0.006)								
Test for subgroup differences: Chi² = 9.41, df = 1 (P = 0.002), I² = 89.4%								



Note. Forest plot of non-pharmacological interventions on sleepiness on-shift according to the outcome measures (non-pharmacological intervention vs. no intervention). We performed a sensitive analysis for KSS subgroup by removing one study that had highly heterogeneous result (Zion et al., 2019). *Acronyms*. KSS, The Karolinska Sleepiness Scale; SSS, the Stanford Sleepiness Scale

국문 초록

야간 근무자의 수면 장애에 대한 비약물적 중재의 효과: 체계적 문헌고찰 및 메타분석

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야간 근무자는 일주기 불균형으로 인하여 일반 낮 근무자에 비해 수면 장애가 심한 것으로 보고되었으며, 이는 심혈관 질환, 비만, 암, 우울증 및 비만과 같은 신체적, 정신적 건강 문제와 연관성이 있는 것으로 알려져 있다. 2007 년 국제 암 연구 기관 (International Agency for Cancer)이 야간 근무를 포함하는 교대 근무가 발암 가능성이 있는 것으로 분류 한 이후, 많은 연구자들은 야간 근무자들을 대상으로 비약물적 수면 중재 효과를 조사하기 위한 임상 실험을 실시했다. 여러 비약물적 수면 중재 효과를 평가한 연구는 많음에도 불구하고 이러한 중재를 종합적으로 검토하고 효과의 크기를 분석한 연구가 부족한 실정이다. 따라서 본 연구는 체계적 문헌고찰 및 메타분석을 통해 그 동안 축적된 야간 근무자를 대상으로 수면 장애를

해결하기 위한 비약물적 중재를 실시한 연구를 평가, 종합, 분석하여 과학적인 근거를 제시하고자 시도되었다.

본 연구의 설계, 수행, 보고의 전 단계는 중재연구에서의 메타분석 가이드라인인 PRISMA 를 적용하여 확인하는 과정을 거쳤으며, 계획 단계에서 연구의 주요 질문 및 선택 기준은 PICOTS-SD 를 기반으로 선정하였다. PICOTS-SD 의 각 구성 요소를 나타내는 주요 개념어는 중심 주제어와 자연어를 사용하여 MEDLINE, EMBASE, CINAHL, PsychINFO 검색엔진, 수면 관련 국제 저널 및 회색 문헌을 검색하였다. 본 연구에서 문헌의 질과 잠재적 비뚤림 평가는 Cochrane Risk of Bias 도구를 활용하여 시행하였다.

선택·배제 기분에 따라 총 28 편의 문헌이 추출되었으며, 그 중 20 편의 문헌이 메타분석에 포함되었다. 랜덤효과모형을 이용하여 전반적인 수면 장애에 대한 비약물적 중재의 효과 크기, 수면 장애 종류에 따른 비약물적 중재의 효과 크기, 비약물적 중재 방법에 따른 효과 크기 및 직업 종류에 따른 효과 크기를 산출하였다. 메타분석 결과, 야간 근무자의 수면 장애에 대한 비약물적 중재의 효과 크기는 Hedges' g −1.43 (95%CI: −2.34, −0.53)로 통계적으로 유의한 것으로 나타났다. 수면 장애 종류별로 분석한 결과, 근무 중 졸림 (Hedges' g= −2.83, 95% CI: −4.55, −1.10), 수면의 양 (Hedges' g= 0.76, 95% CI: 0.15, 1.37), 수면의 질 shift (Hedges' g= −0.57, 95% CI: −0.81, −0.34)로 통계적으로 유의한 효과 크기를 나타냈다. 비약물적 중재 방법 중 빛 요법 (Hedges' g= −1.62, 95% CI: −2.81, −0.43)은 통계적으로 유의한 효과 크기를 나타냈으나, 근무 중 낮잠과 행동 중재 프로그램은 통계적으로 유의한 효과를 나타내지 않았다. 직업 종류에 따른 분석 결과, 의료계에 종사하는 야근 근무자와 산업 및 제조업에 종사하는 야간 근무자에게서 비약물적 중재는 유의한 효과를 나타냈다.

본 연구의 결과는 야간 근무자의 수면 장애 완화에 비약물적 중재가 유의한 효과가 있음을 시사한다. 또한, 수면 장애 완화 효과는 의료계, 산업 및 제조업에 종사하는 야간 근무자에게 빛 요법을 적용했을 때 가장 큰 것으로 보인다. 본 연구 결과는 야간 근로자의 수면 장애 예방 및 완화에 다양한 비약물적 중재가 효과적임을 확인함으로써, 실무에서 야간 근로자를 위한 중재를 선택하고 실행하는 데 객관적은 증거를 제공할 수 있을 것이다.

주요어: 야간 근무, 수면, 수면 장애, 수면 일주기 리듬, 체계적 문헌고찰, 메타분석

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