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REVIEW

Effectiveness of bright light exposure, modafinil and armodafinil for improving alertness during working time among nurses on the night shift: A systematic review

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ABSTRACT

Objective: We aimed to evaluate the effectiveness of bright light exposure, modafinil, and armodafinil for improving alertness during working time among nurses on the night shift.

Methods: We carried out a literature search using the PubMed, Scopus, and Web of Science electronic databases regarding articles pertaining to workplace interventions for improving wakefulness among nurses working the night shift using the following medical subject headings: ((((Bright light exposure) OR wakefulness medications) AND Nurses AND Night Shift-work)).

Results: The searches generated a total of 34 records on the PubMed database, 130 on the Scopus database, and 32 on the Web of Science database. A total of 95 studies were identified after removal of duplicates. Nevertheless, the 95 articles were screened, 75 studies were excluded based on the review of titles and abstracts, and further 15 full-text articles were excluded because the studies did not meet the selection criteria. A total of 632 subjects from 5 studies were included.

Conclusion: Bright light exposure is beneficial in improving alertness during the night shift. On the other hand, armodafinil or modafinil taken before the commencement of night shift work is effective in the treatment of excessive sleepiness associated with shift work sleep disorder.

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KEYWORDS
Hospital organization and administration; nurses; night shift-work; circadian rhythm; sleep disorders

Introduction

When it comes to ideal hospital management, it is important to establish a balance between workplace health programs that encourage good sleep and interventions that promote alertness, vigilance, and performance among healthcare workers [1]. Alertness and sleep are determined by the interaction of the endogenous circadian pacemaker and a sleep homeostat [2]. Working night shifts disrupts the circadian rhythm, leading to sleep deprivation among nurses. Sleep deprivation is associated with emotional stress, fatigue, anxiety, and depression. The adverse effect of circadian rhythm disruption causes widespread health problems among nurses working the night shift [2]. Circadian rhythm sleep disorders occur due to the desynchronization between the timing of the intrinsic circadian clock and the extrinsic light–dark and social/activity cycles, resulting in symptoms of excessive sleepiness and insomnia [3]. Changes in the sleep-wake cycle from inconsistencies between work schedules and an individual's circadian rhythm could result in a circadian rhythm sleep-wake disorder known as shift work sleep disorder [4]. Insomnia or excessive sleepiness is one of the criteria required to make a diagnosis of circadian rhythm sleep-wake disorders [5]. According to the third edition of the international classification of sleep disorders, the diagnosis of shift work sleep disorder is made when the diagnosing criteria are met over a period of at least 3 months [5]. Sleepiness during the night shift is common among nurses and can be dangerous because it leads to medical errors (e.g. medication administration errors, needle stick injuries, poor patient management). Through evidence-based workplace health initiatives, healthcare facility managers can assist nurses in increasing their vigilance during the night shift. Hence, the use of pharmacological and non-pharmacological interventions that can help reinstate the circadian rhythm alignment and minimize sleepiness and fatigue is important for the promotion of workplace health and safety [6]. The process of increasing the brightness of artificial light in the working environment at night in order to induce the stimulating effects of bright light on subjective alertness and improve job performance by counteracting the effects of sleep deprivation and/or the circadian trough on alertness is recognized as bright light exposure. Moreover, bright light therapy is a non-invasive therapy that can be used to adjust the circadian rhythms,

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sleep, mood, and serotonin pathway [7]. Wakefulness-promoting medications (modafinil and armodafinil) may improve wakefulness by altering the noradrenergic and dopaminergic systems, and possibly by interacting with the hypocretin/orexin system [8]. Modafinil (Provigil) and its R-enantiomer armodafinil (Nuvigil) have been studied in patients with excessive sleepiness associated with shift work sleep disorder and have been shown to increase alertness, vigilance, and quality of life. Modafinil and armodafinil do not bind to dopamine receptors directly, rather they inhibit the dopamine transporter, which influences the dopaminergic system. The CYP450 isoenzymes are involved in the metabolism of modafinil and armodafinil [8]. The objective of this review was to evaluate the effectiveness of bright light exposure, modafinil, and armodafinil for improving alertness during working time among nurses on the night shift.

Methods

We carried out a literature search using the PubMed, Scopus, and Web of Science electronic databases regarding articles pertaining to workplace interventions for improving wakefulness among nurses working the night shift using the following medical subject headings: ((((Bright light exposure) OR wakefulness medications) AND Nurses AND Night Shift-work)). The literature searches were completed on January 5, 2021. Only articles published in English were included.

Inclusion criteria

Randomized controlled trials and intervention studies which conducted primary investigations on the efficacy of bright light exposure, and modafinil and armodafinil in improving wakefulness among night-shift nurses and shift workers, respectively which were published in English until December 2021 were included.

Exclusion criteria

Case reports, case series, narrative reviews, literature reviews, and opinion papers were excluded. Original articles which did not report the efficacy of bright light exposure, modafinil and armodafinil, among night-shift nurses and shift workers were excluded.

Search outcomes

A total of one hundred and ninety-six papers were initially identified from various database searches, out of which 101 were duplicates. After thorough screening of 95 papers based on the inclusion and exclusion criteria, 5 papers were finally selected for the systematic review. The PRISMA flowchart for the selection is shown in Figure 1.

Quality appraisal

The quality of the studies was assessed using the study design-specific tool developed by the National Heart, Lung, and Blood Institute and Research Triangle Institute International [9]. We gave point values (e.g. No = 0, Yes = 1, Good = 2, Fair = 1, Poor = 0) to each assessment of quality and summed them for the final quality score, so that the higher the total score, the better the quality of study (Table 1). Two authors (CEO & CEO) reviewed the selected papers independently and unanimously approved the five papers for the review. Due to the heterogeneity of the papers which differed in their methods and interventions regarding this topic, we decided to conduct a systematic review to assess the efficacy of bright light exposure, modafinil and armodafinil for improving wakefulness among nurses working night shifts.

Synthesis and extraction

Two authors (CEO & CEO) extracted data from the studies which was later reviewed and discussed by all the authors. The data were synthesized via a descriptive approach, which involved a systematic description of a summary of the findings with tabulation of data. The objective of the descriptive synthesis was to organize the findings and evaluate the effects of the interventions used in the various studies. The interventions included the use of bright light exposure, and armodafinil and modafinil respectively.

Results

Evaluation of study design

The searches generated a total of 34 records on the PubMed database, 130 on the Scopus database, and 32 on the Web of Science database. A total of 95 studies were identified after removal of duplicates. Nevertheless, the 95 articles were screened, 75 studies were excluded based on the review of titles and abstracts, and further 15 full-text articles were excluded because the studies did not meet the selection criteria. A total of 5 studies were selected based on the objective of this systematic review. See Figure 1 for the literature search and selection strategy. A total of 632 subjects from 5 studies were included. There were 3 studies that reported the efficacy of bright light exposure in improving alertness and reducing sleepiness among nurses working night shifts. Two studies reported the efficacy of modafinil and armodafinil in the management of excessive sleepiness

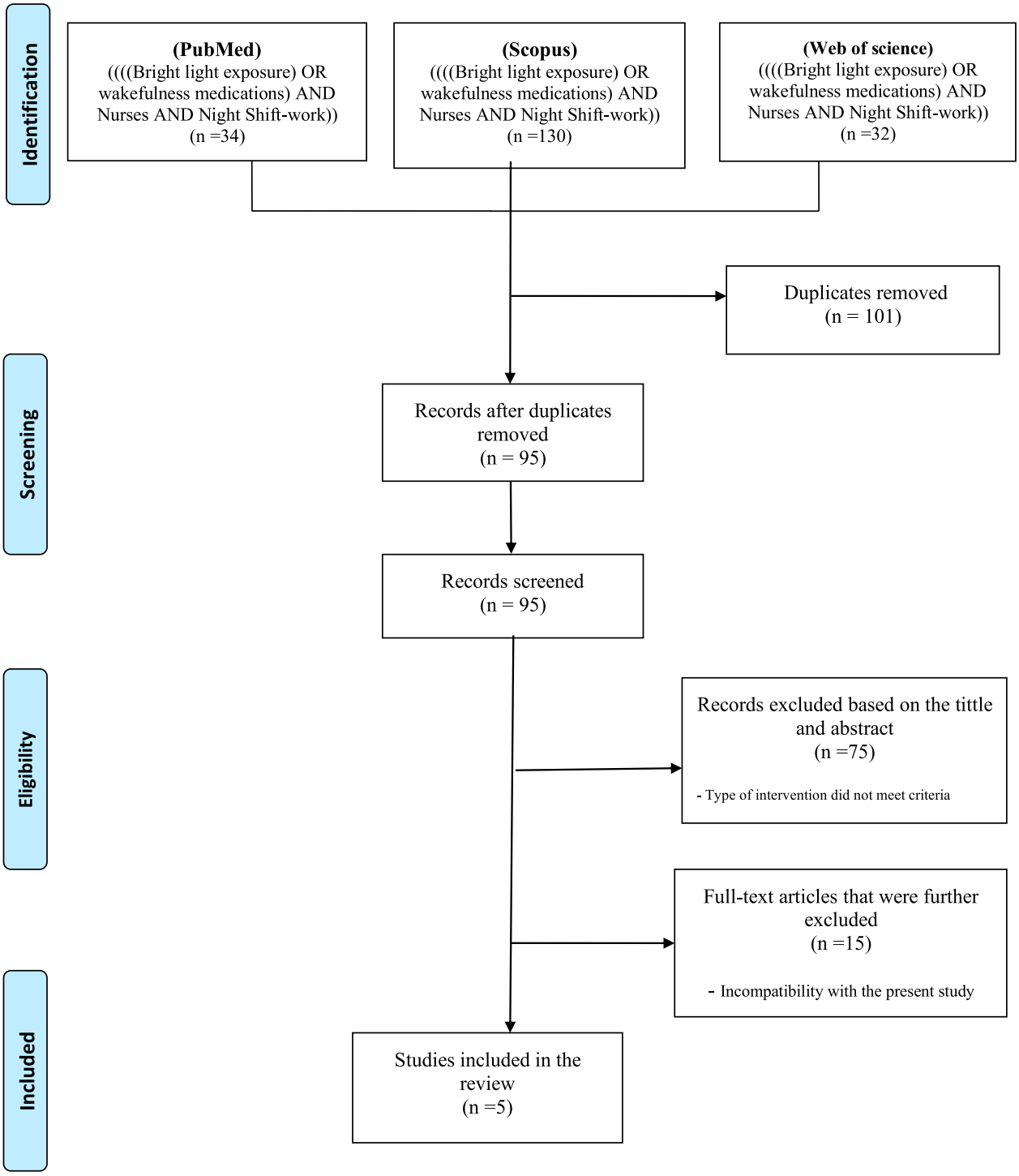

Figure 1. PRISMA flow-chart of search strategy.

Table 1. Quality Scores of studies on the effectiveness of bright light exposure, modafinil and armodafinil for improving alertness during working time among nurses on the night shift.

Author (Year)	Quality Score
Griepentrog et al. [14]	10
Huang et al. [15]	9
Kakooei et al. [16]	9
Czeisler et al. [27]	10
Czeisler et al. [25]	10

Note: Study design-specific tool developed by the National Heart, Lung, and Blood Institute (NHLBI) and Research Triangle Institute International (NIH National Heart, Lung and Blood Institute, 2021).

during working hours among shift workers with shift work sleep disorder (see Table 2).

Bright light exposure's effectiveness in improving alertness and reducing sleepiness during working hours among nurses working the night shift

The efficacy of bright light exposure in resetting the circadian clock is dependent on the dose of the light stimulus applied (light intensity, wavelength spectrum, illumination, and duration), time, and

individual circadian rhythms [7]. However, timed bright light exposure may not be sufficient to shift the melatonin rhythm completely into the sleep episode, but it can significantly phase-delay dim light melatonin onset. According to one study conducted by some Finnish researchers, eighty-seven healthy female nurses were actively exposed to brief periods of bright light (5000 lux) at planned intervals during each night shift during a two-week period [10]. The participants completed self-assessment questionnaires each morning after a night shift, evaluating subjective symptoms and discomfort brought on by night work. The questionnaires were also completed 2 weeks before and after the bright light session. Summer (May-June) and winter (November-December) were the two stages of the research [10]. A total of thirty-seven nurses participated in the study in both seasons. Bright light exposure, regardless of the age of the participant, significantly reduced the subjective distress associated with nightshift work in both summer and winter. Those who reported seasonal changes on a regular basis had a greater benefit. Moreover, Short pulses of timed bright-light exposure during the night duty may enhance nurses' adaptation to night shift work [10]. One meta-analysis showed that medium-intensity light therapy for a shorter duration effectively reduced sleepiness among shift workers on the night shift [11]. On the other hand, the results of another meta-analysis showed that exposure of night shift nurses to bright light could decrease sleepiness and improve alertness during night shifts [12]. Timed bright light exposure significantly phase shifts the circadian system, improves sleep, and performance in a simulated night shift experiment [13]. The outcomes of the above-mentioned studies seem to be in accordance with those of our selected studies regarding the efficacy of bright light exposure in improving alertness during working time among nurses on the night shift. Griepentrog et al., found that nurses working the night shift may improve their night-time alertness and daytime sleep through exposure to a bright light environment in their workplace [14]. Griepentrog and colleagues found that exposure to high illuminance lighting relative to standard hospital lighting significantly reduced subjective sleepiness among nurses working in the intensive care unit at the end of the night shift [14]. These improvements may be increased by reducing exposure to morning light on the way home [14]. Huang et al., on the other hand, conducted their study in a hospital; nurses in the treatment group were exposed to artificial bright light ranging from 7000–10,000 lux for ≥30 min; evening shift exposure occurred between 19:30 and 20:30, and night shift exposure occurred between 23:00 and midnight [15]. The participants were writing or reading during the exposure. An Apollo briteLITE 6 was used to produce illumination. Just above eye level, a light box was put at a 45-degree angle from the face. At roughly 70 cm between the light box and the nurses, a light intensity of 7000–10,000 lux could be delivered. A Lutron Electronic LX-1102 light meter was used to evaluate light intensity. At night, ward illumination was kept to a minimum [15]. In the hospital, ward illumination was kept between 100 and 400 lux at night. The individuals were treated for ≥10 days over the course of two weeks, and daytime outdoor sun exposure after work and before bedtime was prevented by wearing dark sunglasses with ultraviolet protection, even on off days. The subjects in the control group were not exposed to artificial bright light, although they did wear sunglasses after work and before bed to avoid outdoor sun exposure. The outcome of the study by Huang and colleagues showed that exposure to bright light of 7000–10,000 lux for at least 30 min at night combined with reduced exposure to light in the morning after the night shift was effective in improving sleep quality and mental health among nurses working the night shift [15]. Furthermore, according to Kakooei et al., Nurses at a university teaching hospital were tested and exposed to bright light at an intensity of 4,500 lux or poor lighting at an intensity of 300 lux during two breaks (21:15–22:00 and 3:15–4:00). [16]. The nurses were observed for 24 h while at work, and their plasma cortisol and melatonin levels were examined at 3-hour intervals, as well as their body temperature. The Karolinska sleepiness scale was used to assess subjective alertness. The amount of melatonin produced at night was significantly reduced after being exposed to bright light. Bright light raised cortisol levels and body temperature, as well as considerably improved alertness, according to a one-way ANOVA test, suggesting that bright light exposure at a modest intensity in a healthcare setting can have a major impact on circadian rhythm adjustment thus improving alertness among nurses [16]. According to the outcome of the investigation carried out by Kakooei and colleagues' exposure to bright light at an intensity of 4,500 lux twice during the night shift (21:15–22:00 and 3:15–4:00) significantly improved alertness and reduced sleepiness among nurses working the night shift [16]. Moreover, accurately timed exposure to bright light can shift the sleep-wake cycle to earlier or later times to balance the misalignment between the circadian system and the anticipated sleep-wake schedule [17]. Bright light therapy significantly improves individual ratings of alertness, as well as objective measures of arousal and performance [18]. Bright light therapy reduces sleepiness, improves reaction time, and may help reduce fatigue and decreases in job performance related to shiftwork [18,19]. The side effects of the most prescribed dose and duration of bright light therapy (10,000 lux for 30 min) are eye strain and blurred vision, headaches, irritability,

Table 2. Characteristics of included studies and summary of some evidence on the effectiveness of bright-light exposure and wakefulness-promoting medications in mitigating sleepiness.

Author (Year) Country	Sample size	Aims	Study design	Interventions	Results	Comment
1. Griepentrog et al. [14] United States of America	43	To determine whether prolonged exposure to bright light during a night shift reduces sleepiness and enhances psychomotor performance among nightshift intensive care unit nurses.	A single-center randomized, crossover clinical trial. Nurses working the night shift were exposed to a 10-h period of high illuminance (1500–2000 lx) white light compared to standard ambient fluorescent lighting of the hospital.	**Non-pharmacological intervention** (Bright light exposure).	When exposed to high illuminance lighting, the subjects experienced reduced sleepiness scores based on the Stanford sleepiness scale than when exposed to standard hospital lighting.	A bright lighting environment for intensive care unit nurses working the night shift reduces sleepiness.
2. Huang et al. [15] Taiwan	92	To determine whether bright light exposure during the first half of the evening/night shift combined with light reduction in the morning is effective in reducing sleep problems among nurses.	Female hospital nurses on rotating shifts during the evening or night shift with an Insomnia Severity Index score > 14 were enrolled. Subjects in the treatment group were exposed to bright light at 7000–10,000 lux for ≥30 min. Exposure was continued for at least 10 days during the 2-week experiment, and the subjects avoided daytime outdoor sun exposure after work by wearing dark sunglasses.	**Non-pharmacological intervention** (Bright light exposure).	Bright light therapy of 7000–10,000 lux for at least 30 min at night for at least 10 days for 2 weeks significantly attenuated sleep problems in nurses working the evening or night shift.	Bright light exposure decreased anxiety and depression by mitigating insomnia among shift nurses.
3. Kakooei et al. [16] Iran	34	To evaluate the effects of bright light on the rhythms in body temperature, plasma melatonin, plasma cortisol and subjective alertness among nurses during night shift.	The subjects were assessed under 24 h during which their plasma cortisol and plasma melatonin levels were measured at 3 h intervals. The night shift nurses were exposed to bright light (4500 lux) during two break times (21:15–22; 00 and 3:15–4:00) for four consecutive weeks.	**Non-pharmacological intervention** (Bright light exposure).	Bright light exposure increases cortisol levels and body temperature and improves alertness among nurses on the night shift.	Bright light exposure is a promising strategy to improve alertness and reduce sleepiness among nurses working night shifts.
4. Czeisler et al. [27] United States of America	254	To assess the effect of armodafinil, 150 mg, on the physiologic tendency for sleep and cognitive performance during normal night shift hours among patients with excessive sleepiness associated with chronic shift work sleep disorder.	Patients received armodafinil, 150 mg, or placebo 30–60 min before each night shift for 12 weeks.	**Pharmacological intervention** (armodafinil).	Armodafinil significantly reduced sleepiness during the night shifts, improved memory performance and attention compared with placebo.	Armodafinil significantly improved wakefulness during scheduled night work. Armodafinil can be an effective treatment for excessive sleepiness associated with shift work sleep disorder among nurses working night shifts.
5. Czeisler et al. [25] United States of America	209	To evaluate the efficacy of modafinil for the treatment of sleepiness among patients with shift work sleep disorder.	This is a double-blind randomized trial. Patients with shift-work sleep disorder received either 200 mg of modafinil or a placebo before the start of each shift.	**Pharmacological intervention** (modafinil).	Treatment with modafinil, as compared with placebo, resulted in a moderate improvement from baseline in mean nighttime sleep latency.	Treatment with 200 mg of modafinil moderately decreased excessive sleepiness among shift workers with shift work sleep disorder.

and nausea [20]. No study has reported any severe effects of bright light therapy.

Modafinil and armodafinil's efficacy in the management of excessive sleepiness during working hours in night shift workers with shift work sleep disorder

The United States food and drug administration (FDA) approved modafinil and armodafinil for the treatment of shift work sleep disorder, and they can be taken approximately one hour before the beginning of shift work [21]. Modafinil increased alertness, vigilance, and executive function during simulated night shifts [22]. Caution needs to be taken, however, as prolonged use could lead to physical dependence and tolerance, with withdrawal symptoms observed on abrupt cessation of modafinil [23,24]. Two different double-blind randomized controlled trials were done to study the efficacy of modafinil for the treatment of excessive sleepiness associated with shift work sleep disorder, and both studies showed a significant improvement in the quality of life, wellbeing, and the reduction of excessive sleepiness among patients with shift work sleep disorder [25,26]. According to Czeisler et al., treatment with modafinil resulted in a slight reduction in mean nighttime sleep latency from baseline when compared to placebo, and more patients had improvement in their clinical symptoms [25]. Patients on modafinil showed fewer declines in attention during nocturnal testing of their performance on the Psychomotor Vigilance Test, and correspondingly fewer patients reported having had crashes or near-accidents while driving home [25]. However, residual sleepiness was observed, especially during the last one-third of the night shift work hours, which compelled the decision to develop better interventions [25]. Hence, some studies evaluated the efficacy of armodafinil, which is an R-isomer of modafinil, which led to its approval by the FDA. These randomized control trials showed that armodafinil also significantly improved the wakefulness, attention, long-term memory, and overall performance of people with shift work sleep disorder [27,28]. According Czeisler and colleagues, armodafinil significantly improved mean sleep latency all through normal night shift hours in patients with excessive sleepiness associated with chronic shift work disorder (≥3 months) of modest or more severity from 2.3 (1.6) minutes at baseline to 5.3 (5.0) minutes at final visit, compared with a change from 2.4 (1.6) minutes to 2.8 (2.9) minutes in the control group. When compared to the control, more patients taking armodafinil (79%) improved their clinical status (59%) [27]. Armodafinil significantly reduced sleepiness throughout the night shifts, and the trip home, according to patient health records. When compared to placebo, armodafinil increased performance on conventional memory and attention tests. As measured by polysomnography, armodafinil was well tolerated and had no effect on daytime sleep [27]. Remarkably, several nurses who are experiencing excessive sleepiness during the night shift request prescriptions for armodafinil to improve vigilance [29]. Further studies showed that Armodafinil 150 mg administered at the onset of a night shift increased alertness and cognitive performance in shift workers with shift work sleep disorders, implying that armodafinil can bring nocturnal alertness levels to normal daytime levels in most night shift workers with excessive sleepiness [30]. On the other hand, a study which compared the effectiveness of armodafinil with modafinil in the treatment of excessive sleepiness in patients with shift work sleep disorder demonstrated that the efficacy, safety, and incidence of adverse effects of both medications were comparable [31]. The common side effects related to armodafinil and modafinil are dizziness, headaches, nausea, and insomnia. However, armodafinil was shown to have higher plasma concentrations later in the day than modafinil, explaining the reason why armodafinil is generally preferred for the reduction of excessive sleepiness in patients with shift work disorder compared to modafinil [32,33].

Discussion

Sleepiness is recognized to have a negative impact on nurses' health and well-being when they work night shifts. It's been linked to poor safety outcomes, and it's a recognized workplace hazard among night shift nurses and midwives at a National Health Service hospital trust in the United Kingdom [34]. Nurses working regular night shifts may experience considerable disruptions in their daytime sleep, particularly in terms of sleep duration, which is significantly less than night sleep, this could be attributed to attending to vital daytime needs [35]. Occupational medicine practitioners often use both pharmacological and non-pharmacological interventions to improve wakefulness among nurses on the night shift. However, the effectiveness of most wakefulness-promoting interventions is frequently criticized worldwide. However, the use of illumination initiatives to produce valuable advantages for night workers is getting prominence. In humans, exposure to light does have the capacity to entrain the endogenous circadian clock, and as a result, it can be used to promote circadian adaptation to a night shift schedule. Furthermore, light has a transient alerting effect that can help to increase performances and lessen vigilance deficiencies during the night shift. Several aspects of light, such as timing, intensity, and wavelengths, are being used to create these effects. New techniques for workplace lighting are continuing to emerge as light emitting diode

technology advances. Bright light's circadian phase shifting, and alerting effects are dependent on its timing, intensity, duration, wavelength, as well as individual variation and response to light [36]. To achieve the desired outcome of increased alertness and vigilance during the night shift, bright light exposure should be timed to phase delay the circadian rhythm in coherence with the estimated nurses' exact circadian phase, which are the nadir of the core body temperature rhythm and melatonin rhythm [36]. A team of researchers assessed the spectral sensitivity of phase resetting, melatonin suppression, and alertness induced by intermittent light pulses. They exposed 12 subjects to six monochromatic light pulses (2.8×1013 photons/cm^2/s) over a 6.5 h window during the biological night. 6 subjects received 6×15-minute 460 nm (blue) pulses, and the other 6 subjects received 6×2-minute 555 nm (green) light pulses. Results were compared to chronological data in 16 individuals who received continuous 460 nm ($n = 8$) or 555 nm ($n = 8$) light exposure using an identical protocol [37]. The outcome of their study was that long-duration continuous 460 nm light exposure induced the largest total phase delay shifts, but intermittent 555 nm light induced the largest phase delay shifts per minute of the photic stimulus. Melatonin suppression was significantly higher under continuous light exposure compared to intermittent exposure patterns and for 460 nm versus 555 nm exposure (under both light patterns) [37]. Intermittent light exposure can cause the human circadian pacemaker to readjust to a stable phase. While stimulation of cone photoreceptors generates the most efficient rate of phase resetting per unit time during a short period, activation of intrinsically photosensitive retinal ganglion cells with short-wavelength blue light induces more robust and prolonged relative responses [37]. Among operational national aeronautics and space administration flight controllers working overnight shifts, short wavelength-enriched white light and exercise improve alertness, mood, and performance. The subjects were exposed to blue-enriched polychromatic lighting for three 20-minute intervals, each with ten minutes of exercise, before and twice during their shifts [38]. In this systematic review, we examined three studies that investigated the effectiveness of bright light exposure for improving alertness during working time among nurses on the night shift. All 3 studies showed that exposure of nurses to bright light of moderate- to high illuminance significantly improved alertness and decreased sleepiness among nurses on the night shift when compared to dim light [14–16]. However, exposure to bright light of high illuminance in the workplace may reduce psychomotor performance [15].

Modafinil (Provigil) and armodafinil (Nuvigil) are non-amphetamine central nervous system stimulants that can be used to treat excessive sleepiness caused by shift work sleep disorder. While modafinil is a racemic molecule, armodafinil is the (R)-enantiomer of modafinil [39]. Both medicines have the same pharmacologic qualities and are equally effective and safe. Prenatal exposure to modafinil or armodafinil appears to raise the chance of significant congenital abnormalities, so these drugs should be avoided during pregnancy [39]. Modafinil inhibits dopamine and noradrenaline absorption in the region of the hypothalamus involved in sleep induction and is safer and more effective and less addictive than other central nervous system stimulants [40]. Common adverse effects and rare life-threatening occurrences linked to modafinil and armodafinil include cardiovascular, mental, and cutaneous hypersensitivity reactions. Non-prescription use of these drugs is frequent among night shift workers, and this is a cause for concern not only because it is uncontrolled, but also because adverse effects are more common when either modafinil or armodafinil are used off-label or without a prescription [40]. In this systematic review, we evaluated 2 studies that investigated the efficacy of Modafinil and Armodafinil for treatment of excessive sleepiness associated with shift work disorder, and both drugs were found to be effective [25,27]. However, excessive sleepiness and impaired nocturnal performance were still observed in modafinil-treated patients [25]. When compared to a placebo, modafinil had no effect on daytime sleep, and headaches were the most common side effect. Furthermore, during night-time assessment of modafinil effect on psychomotor performance using the Psychomotor Vigilance Test, patients on modafinil had a lower frequency and duration of lapses in attention [25]. Armodafinil, on the other hand, improved wakefulness during scheduled night work, elevating mean night-time sleep latency over the range determined to imply severe daytime sleepiness. Armodafinil significantly improved general clinical conditions, long-term memory, and attention [27].

Night shift work upsets circadian sleep and alertness cycles, resulting in a lack of sleep during the day and increased drowsiness during the work shift. The misalignment of the needed sleep and wakefulness schedule with the endogenous circadian rhythm is the primary cause underlying shift work sleep disorder. As a result, circadian phase shifting is a reasonable management strategy. However, entraining a shift worker to a permanent night-work/day-sleep pattern, is often difficult because most workers want to engage in social and family activities on their days off. The combination of intermittent bright light exposure with the use of modafinil and armodafinil may be more effective in improving alertness during working hours and quality of life among nurses with shift work sleep disorder. Furthermore, hospital management

and nurse managers can use e-learning and video platforms to train nurses on how to adapt to the night shift in this era of Omicron surge, and on how to become more aware of the potential negative physical and mental impacts of working night shifts, rotating shifts, and extended work hours, as well as how these consequences may affect their job performance [41]. Nurses can consider various ways to improve their sleep quantity and quality. They can be counseled on feeling more vigilant on the work and having fewer on-the-job accidents or injuries. The e-learning platforms can be used to teach strategies for preventing drowsy driving on the way to and from work, as well as how to improve one's well-being and health by engaging in regular physical activity, nutritional enhancements, and improving personal relationships and quality of life [42].

Recommendations for nursing management

Bright light exposure before and during the night shift, scheduled naps (15–20 min) during the night shift, and the use of wakefulness-promoting medications (modafinil or armodafinil) only on doctor's prescription for individuals diagnosed with shift work sleep disorder can help to improve alertness, job performance, and physical and mental wellbeing among nurses working the night shift. However, an integrated lifestyle intervention involving dietary modification, physical activity, weight reduction/healthy weight maintenance, smoking and alcohol cessation, cognitive–behavioral therapy, mindfulness meditation, and stress management can also improve alertness, sleep quality, and physical and mental health among nurses working night shifts. Furthermore, nurses working the night shift should be continuously educated about shift work sleep disorder and newest strategies to improve circadian alignment, decrease sleepiness during the night shift and minimize the risk of chronic diseases associated with night shift work. Nurse managers can also facilitate the referral of nurses to sleep medicine consultants if they notice symptoms of shift work sleep disorder among nurses on the night shift.

The findings of this paper redound to patient safety and well-being because of increased nurses' vigilance at the bedside during the night shift. The rigorous nature of nurses' work, which includes increased workload and stress, as well as the sleep deprivation associated with working the night shift, means that nurses themselves are at risk of committing errors such as equipment operational errors and medication administration errors, while providing routine care to patients. The use of bright light exposure, modafinil, and armodafinil to improve vigilance during working time among nurses on night shift increases night nurses' attentiveness and ability to identify clinically significant observations, signals, and cues; improves the ability to communicate information to patients and families; enhances the calculation of risk involved in nursing practice situations; and readiness to act appropriately and efficiently to minimize risks and respond to threats and emergencies during the night shift; maintains nurses' clinical competence to operate hospital facilities' equipment to reduce the likelihood of injury to patients and staff, minimizes patient documentation errors due to sleepiness, improves responsiveness to patient preferences, values, and needs; reduces waiting and delays that may be harmful due to lack of alertness, especially during an emergency situation at night.

Future perspectives

Bright light therapy is a promising non-pharmacological therapy for increasing nocturnal alertness and decreasing sleepiness among nurses working night shifts. However, there is a need for further studies on bright light therapy, such as experimental studies with animal models, and well-designed randomized control trials with larger sample sizes using multiple light levels, so that a safe and efficacious high-intensity bright light therapy regimen can be established and recommended. Bright-light exposure during a night shift can alleviate the nocturnal decrements in alertness and performance. However, its adverse effects on mood state and cognition should be properly studied. More randomized controlled trials are also needed to examine the efficacy of wakefulness promoting medications in improving alertness and job performance among night shift nurses diagnosed with shift work sleep disorder as well as their side effects.

Strengths and limitations

This is the first review to principally examine the efficacy of bright light exposure and wakefulness-promoting medications for improvements in alertness during the night shift among nurses. We conducted a complete search and provided an international perspective on this crucial subject. The major limitations of this study were the lack of randomized controlled trials on the efficacy of modafinil and armodafinil in the management of excessive sleepiness among nurses on the night shift, and the efficacy of bright light exposure in improving alertness and vigilance among nurses on night shift.

Conclusions

Addressing workplace vigilance and sleep issues will assist nurses working the night shift to improve their job performance, productivity, and well-being. Excessive sleepiness associated with shift work sleep

disorder in nurses working night shifts could result in adverse physical and mental health conditions, as well as increased healthcare costs from medical errors and work injuries. There is a great need for prompt identification, prevention and treatment of shift-work sleep disorder and its associated symptoms through evidence-based interventions which have been shown to promote wakefulness during work time (e.g. bright light exposure, modafinil, and armodafinil). Exposure to bright light during the night shift may improve alertness by suppressing melatonin secretion and increasing sleep onset latency. Furthermore, wakefulness-promoting medications are used to reduce excessive sleepiness in individuals with shift work sleep disorder, and to reduce the symptoms of this disorder. Armodafinil or modafinil taken before the commencement of night shift work is effective in the treatment of excessive sleepiness associated with shift work sleep disorder. However, armodafinil appears to have longer-lasting effects compared to modafinil.

Practical implications

According to the outcome of this review, bright light exposure during the night can alter the circadian clock, suppressing melatonin production and keeping an individual awake at night, thus making that person sleepier during the day. Technologists specializing in the design of light-emitting diode technology should improve innovations that allow the color and intensity of lighting to automatically change or to be adjusted during the day and night shift to optimize workplace performance. The quality of lighting in a workplace can have a significant effect on productivity. With adequate lighting during the night shift, nurses can perform and concentrate better. Adequate exposure to artificial bright lighting can decrease medical errors as well as eye strain and the headaches and nausea that often accompany eye strain among nurses during the night shift. Increasing the brightness of light during working hours could help decrease chemical hazards among healthcare workers on the night shift. Armodafinil and modafinil may be useful drugs for nurses who suffer from excessive sleepiness due to a chronic shift-work sleep disorder of mild or higher severity because they can help them stay awake during scheduled night shifts. However, Armodafinil and modafinil should not be taken together because both contain similar active ingredients. Armodafinil contains the R-enantiomer of modafinil whereas modafinil contains a racemic mixture of R- and S-modafinil. Armodafinil and modafinil are similar in effectiveness and safety. The effects of armodafinil may last longer compared to modafinil. Armodafinil comes in 50, 150, 200, and 250 mg tablets. For excessive sleepiness due to shift work sleep disorder, the typical dosage of Armodafinil is 150 mg, and for modafinil is 200 mg taken about one hour before the start of the shift respectively.

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