TITLE
Improving fatigue risk management in healthcare: A systematic scoping review of sleep-related/fatigue-management interventions for nurses and midwives.

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Abstract

Background. Nurses and midwives make up almost 50% of the global healthcare shift working workforce. Shift work interferes with sleep and causes fatigue with adverse effects for nurses' and midwives' health, as well as on patient safety and care. Where other safety-critical sectors have developed Fatigue Risk Management Systems, healthcare is behind the curve; with published literature only focussing on the evaluation of discreet sleep-related/fatigue-management interventions. Little is known, however, about which interventions have been evaluated for nurses and midwives. Our review is a critical first step to building the evidence-base for healthcare organisations seeking to address this important operational issue.

Objectives. We address two questions: 1) What sleep-related/fatigue-management interventions have been assessed in nurses and midwives and what is their evidence-base? and 2) What measures are used by researchers to assess intervention effectiveness?

Design & data sources. The following databases were searched in November, 2018 with no limit on publication dates: MEDLINE, PsychINFO and CINAHL.

Review methods. We included: 1. studies conducted in adult samples of nurses and/or midwives that had evaluated a sleep-related/fatigue-management intervention; and 2. studies that reported intervention effects on fatigue, sleep, or performance at work, and on measures of attention or cognitive performance (as they relate to the impact of shift working on patient safety/care).

Results. The search identified 798 potentially relevant articles, out of which 32 met our inclusion criteria. There were 8619 participants across the included studies and all were nurses (88.6% female). We did not find any studies conducted in midwives nor any studies conducted in the UK, with most studies conducted in the US, Italy and Taiwan. There was heterogeneity both in terms of the interventions evaluated and the measures used to assess effectiveness. Napping could be beneficial but there was wide variation regarding nap duration and timing, and we need to understand more about barriers to implementation. Longer shifts, shift patterns including nights, and inadequate recovery time between shifts (quick returns) were associated with poorer sleep, increased sleepiness and increased levels of fatigue. Light exposure and/or light attenuation interventions showed promise but the literature was dominated by small, potentially unrepresentative samples.

Conclusions. The literature related to sleep-related/fatigue-management interventions for nurses and midwives is fragmented and lacks cohesion. Further empirical work is warranted with a view to developing comprehensive Fatigue Risk Management Systems to protect against fatigue in nurses, midwives, and other shift working healthcare staff.

Keywords. Circadian Dysregulation, Fatigue, Night Shift Work, Nurses, Nurse-Midwives, Patient Care, Patient Safety, Rotating Shift Work, Shift Work Schedule, Sleep.

What is already know about this topic?

- Fatigue related to shift working has negative effects on the wellbeing of nurses and midwives and on patient safety and care.
- Fatigue Risk Management Systems have been developed and evaluated in other safety-critical industries but not in healthcare.
- The broader healthcare literature has focussed on the evaluation of discreet sleep-related/fatigue-management interventions; however, little is known about which interventions have been evaluated for shift working nurses and midwives.

What does this paper add?

- A systematic scoping of the literature regarding sleep-related/fatigue-management interventions for nurses and midwives; a crucial first step in developing an evidence-base for healthcare organisations wishing to address this important issue.
- Identification of fatigue reduction and/or mitigation strategies which could be included in more comprehensive Fatigue Risk Management Systems for nurses and midwives.
- The literature on this topic is fragmented and lacks cohesion with gaps identified (no studies in the UK, or in midwives) emphasising the urgent need for more research.

INTRODUCTION

Nurses and midwives are a critical part of the healthcare sector and are the largest group in the health professions. Out of the 43.5 million global healthcare workforce, 20.7 million are nurses and midwives (World Health Organisation, 2016). In the United Kingdom 693,618 nurses and midwives (Royal College of Nursing, 2018) make up 56% of the 1,240,853 strong healthcare workforce (NHS Digital, 2018). Healthcare staff represent a unique subset of the shift working population because of the constantly human-facing nature of their work. Not only do they need to perform the 'task-based' aspects of their work well (evidenced by attentive, accurate care provision), they also need to perform the 'relational' aspects of their roles well and consistently (evidenced by caring, empathic treatment of patients).

In a 24/7 healthcare system, nurses and midwives (along with other healthcare staff) are required to work a myriad of different shift patterns in order to keep services running 24/7 and maintain patient care; they are therefore defined as shift workers. The definition of shift work includes shifts where work time arrangements fall outside of conventional daytime hours. This includes fixed early morning, evening, and night work, as well as rotating shift work whereby employees rotate (alternate) more or less regularly between a day, an evening, and a night shift (Kecklund & Axelsson, 2016). Nearly 20% of the workforce worldwide have work time arrangements outside of the normal workday (07:00h to 18:00h; Wright, Bogan, & Wyatt, 2013). Not only do nurses and midwives work rotating shift patterns (including night shifts), but they may also work extended shift patterns of 12 hours as opposed to standard shift duration of 8 hours.

Why is shift work damaging?

Shift work disrupts the normal sleep-wake cycle, leading to shortened sleep and excessive fatigue (Sallinen & Kecklund, 2010; Wright et al., 2013). At a physiological level, the sleep-wake cycles, hormone secretion, body temperature and blood pressure demonstrate circadian rhythmicity. Ensuring these biological rhythms are synchronised to the 24-h day requires input from environmental cues, such as light exposure and feeding cycles (Fisk et al., 2018). In addition to circadian regulation, sleep-wake cycles are regulated by the homeostatic pressure for sleep, which accumulates over time awake (Borbely, Daan, Wirz-Justice, & Deboer 2016). When individuals work during the day these processes are synchronous, optimising alertness during the day, whilst increasing the pressure to sleep at night. However, working night-shifts or rotating shift patterns, which include night shifts, results in exposure to light during the biological night, eating during the biological night and sleeping during the biological day (Baron & Reid, 2014). Changes in the timing of these behaviours results in misalignment with the endogenous circadian system which contributes to the adverse health consequences of working shifts.

Bright light at night (e.g., while working night shifts) supresses the nocturnal synthesis of the pineal hormone melatonin. Melatonin production is associated with darkness-related behaviours (e.g., the onset of sleepiness), and is additionally protective against oxidative DNA damage. Suppression of melatonin associated with long-term night shift work (Daugaard et al., 2017; Papantoniou et al., 2014), accompanied by the exposure of bright light may result in the accumulation of DNA damage and could partially explain the increased incidence of cancer and other diseases in shift workers. There is also evidence that shift work adversely affects hormone production with increased levels of progestogens and androgens, as well as delayed peak androgen production, in night shift workers compared with day workers (Papantoniou et al., 2015). This increase and mistiming of sex hormone production may also partially explain the increased risk for hormone-related cancers observed in night shift workers (Papantoniou et al., 2015). The cumulative effects of these changes to cellular metabolism may be responsible for the higher incidence of cancer and other health problems noted amongst shift workers including nurses and midwives (Colditz et al., 2016; Gu et al., 2015).

It is important to note though that individual differences exist in people's ability to adapt to shift work. There are a number of factors associated with shift work tolerance including chronotype (people's preferred timing of sleep and activity), gender and age. 'Early' chronotypes (preferring to get up early and go to bed early) appear to have more difficulty adjusting to shift work than late types, reporting higher levels of fatigue on shift, and poorer overall sleep quality (Saksvik, Bjorvatn, Hetland, Sandal, & Pallesen, 2011). Younger workers appear to be more tolerant to the effects of shift work with sleep quality and duration decreasing with age (Saksvik et al., 2011). Women who work shifts tend to report more sleeping problems than men, higher levels of fatigue and report higher usage of hypnotics to induce sleep (Saksvik et al., 2011); this is a particularly important factor considering women make up the majority (e.g., 89.3% in the UK; Royal College of Nursing, 2018) of the nursing and midwifery workforce.

The impact of shift working on nurses and midwives

Increasing evidence indicates that shift work negatively impacts nurses' and midwives' physiology, health, and safety; with knock on effects on patient safety and care. Established in 1976, The Nurses' Health Study has collected data from a cohort of U.S. nurses (n=121,701) including shift work profile and health outcomes. Researchers mining this database have demonstrated that female nurses (n=74,862) working rotating night shifts for >5 years had modest increases in both all-cause and cardiovascular disease (CVD)-related mortality; and women working night shifts for 6–14 or ≥15 years also had higher risk of all-cancer mortality (Gu et al., 2015). Colditz, Philpott, and Hankinson (2016) conducted a review of the data gathered through the Nurses' Health Study (between 1976 – 2016) and reported that in relation to sleep and shift work: too long and too short sleep durations and poorer sleep quality were associated with increased risk of developing Type 2 diabetes; shift work and not sleeping the optimal 8 hours per day was associated with increased risk of coronary heart disease, and that there was a positive association between number of years working rotating night shifts and increased risk of breast cancer. However, recent research conducted on the Generations Study cohort (a cohort study of >113,700 women aged 16 or older from the UK) found no increased risk of breast cancer in relation to being a shift worker in the past 10 years (Jones et al., 2019).

In addition to these epidemiological findings, results from empirical papers have shown that nurses and midwives who work shifts including night shifts report significantly poorer sleep quality and reduced sleep duration (e.g., Garde et al., 2003), increased fatigue (e.g., Oyane et al., 2013), gastrointestinal problems (e.g., Saberi & Moravveji, 2010), increased risk for Irritable Bowel Syndrome (Kim et al., 2013), hormonal imbalance (e.g., Davis, Mirick, Chen, & Stanczyk, 2012), and increased anxiety and other mood disorders (e.g., Oyane, Pallesen, Moen, Akerstedt, & Bjorvatn, 2013; Ruggiero, 2003). Furthermore, approximately 30% of shift working nurses report symptoms of shift work disorder (SWD) - a sleep disorder characterized by sleepiness and insomnia which can be attributed to the person's work schedule - with the highest prevalence of symptoms observed in nurses working shift patterns including night shifts (e.g., see Flo et al., 2012).

Alongside the impacts to health, the immediate and most observable impact of shift work is in its effect on disturbing sleep and causing fatigue. Fatigue has been defined as a sense of exhaustion, tiredness, sleepiness, or lack of energy that can result in distress or burnout (Raftopoulos, Charalambous, & Talias, 2012; Shen, Barbera & Shapiro, 2006). Fatigue has been identified as a contributing factor in accidents, injuries and death in a wide range of safety-critical settings including transport operations such as road, aviation, rail and maritime (Williamson et al., 2011), and other occupational settings (e.g., hospitals, emergency operations, law enforcement). The most important effects of fatigue include decreased task motivation, longer reaction times, reduced alertness, impaired concentration, poorer coordination, problems with memory and information processing, and poor judgment (Lerman et al., 2012; Sadeghniiat-Haghighi & Yazdi, 2015).

Fatigue in nurses has been recognised as a threat to nurses' personal safety and patient safety and care (American Nurses Association, 2006a, 2006b). Increased levels of fatigue negatively impact on nurses' neurocognitive functioning which can hinder work performance (Geiger-Brown et al., 2012); and extreme fatigue in nurses has been associated with occupational injuries such as back, neck, and shoulder musculoskeletal disorders and needlestick injuries (Kunert, King, & Kolkhorst, 2007; Smith, Mihashi, Adachi, Nakashima, & Ishitake, 2006; Suzuki, Ohida, Kaneita, Yokoyama, & Uchiyama, 2005; Swaen, van Amelsvoort, Bültmann, & Kant, 2003). Work schedules, especially those involving long work hours (e.g., 12-h shifts) and rotating shift patterns including night shifts, can lead to nurse fatigue. Nurses working 12-h shift patterns sleep on average only 5 hours between shifts (Geiger-Brown et al., 2012), considerably shorter than the 7 to 9 hours per day for adults recommended by sleep experts (e.g., see National Heart, Lung, and Blood Institute, 2012; National Sleep Foundation, 2015). Over successive shifts with insufficient sleep, both sleep debt and fatigue increases, and research suggests that schedules without sufficient time off between shifts (to rest and restore) have been implicated in increased medication errors (Rogers, 2008) and patient mortality (Trinkoff et al., 2011). Furthermore, studies have shown that nurses working shift patterns which include night shifts report increased risks of making a medication error or nearly making one; increased levels of physical and mental exhaustion; and increased likelihood of "nodding off" while driving home after nights shifts (Gold et al., 1992; Dorrian et al., 2006). Studies have also shown that sleep loss profoundly impacts emotional empathy (e.g., see Guadagni, Burles, Ferrara, & Iaria, 2014), a fundamental aspect of nursing and midwifery which has the potential to negatively impact social interactions with patients, leading to patient dissatisfaction.

Therefore, alongside the damaging effects of shift work on nurses' and midwives' health, compromised sleep and resultant fatigue could be implicated in increased likelihood of making errors at work, or of missing someone else's error, which could have serious implications for patient care and safety.

Reducing and mitigating fatigue

Fatigue Risk Management Systems which include procedures and measures for monitoring sources of fatigue, fatigue levels, and related consequences have been implemented in a variety of safety-critical industries and sectors (e.g., aviation, manufacturing, transport, the military). However, the healthcare sector is widely understood to be 'behind the curve' in this respect (Gander et al., 2011; Steege, Rainbow, Pinekenstein, & Kundsen, 2017; Williamson & Friswell, 2013). There is very little in the published literature focussing on such wider Fatigue Risk Management Systems in healthcare, nor much evidence regarding which interventions have been evaluated for shift working nurses and midwives, hence the need for this review.

Fatigue Risk Management Systems aim to reduce the incidence of fatigue and/or to mitigate the effects of fatigue. To reduce the incidence of fatigue, Fatigue Risk Management Systems includes strategies that: 1) ensure the provision of adequate sleep opportunities for employees (e.g., provision of safe sleep spaces on shift for napping, organising shifts so that there is adequate time between shifts for restorative sleep to occur); 2) confirm that adequate sleep has been obtained and that employees are fit for duty (e.g., assessing maximum and minimum sleep achieved in a 48-h period); and 3) detect behavioural symptoms of fatigue (e.g., by using fatigue-measurement instruments/checklists to evaluate whether cumulative fatigue is in evidence) (Sadeghniiat-Haghighi & Yazdi, 2015). To mitigate fatigue, Fatigue

Risk Management Systems include strategies that decrease the probability that a fatigued worker operating in the workplace will make an error that leads to accident or injury, or that compromises patient care (Sadeghniiat-Haghighi & Yazdi, 2015). Other safety-critical industries (e.g., aviation, manufacturing, transport) schedule lower risk tasks at times when fatigue is higher and schedule higher risk more complex tasks, when fatigue levels are lower (Sadeghniiat-Haghighi & Yazdi, 2015); but in the healthcare sector, where tasks on shift are often dictated by the needs of the patients, it is not possible to schedule specific 'high risk' tasks within daylight hours, with the exception of non-emergent surgeries or treatments.

Instead of developing and evaluating comprehensive Fatigue Risk Management Systems (as in other safety-critical industries), the healthcare sector tends to lean towards the implementation and evaluation of discreet countermeasures (interventions) which aim to mitigate the psychological and physiological effects of shift work. Caffeine remains one of the most researched and implemented fatigue countermeasures (Mclellan, Riviere, Williams, McGurk, & Lieberman, 2018). Other interventions, such as appropriately timed melatonin supplementation, bright light therapy, dark googles/sunglasses, and effective organisations of shifts to enable adequate restorative sleep, aim to attenuate the impact and severity of chronic circadian misalignment and sleep deprivation (Caldwell, Caldwell, & Schmidt, 2008). Bright light exposure works to hasten resynchronisation of circadian rhythms, aiding in the physiological adaptation to a new schedule, i.e., returning to day shifts following night shifts (Kolla & Auger, 2011). Bright light exposure has the additional advantage of increasing alertness, which may reduce work place errors (Fisk et al., 2018). Administration of a pharmacological dose of melatonin also induces circadian phase shifting, in a dose-controlled manner (Liira et al., 2012). Another feasible method of managing fatigue on shift is appropriately timed napping (Driskell & Mullen, 2005); and both prophylactic (before shift) and mid-shift naps have been shown to increase alertness and improve performance during the night shift (Slanger et al., 2016).

Review questions and aims

An initial search of the literature yielded no reference to Fatigue Risk Management Systems in healthcare settings, and specifically in relation to reducing or mitigating fatigue in nurses and midwives. There are also no existing published reviews related to this topic for nurses and midwives. However, given that healthcare is a safety-critical industry and given the high risk of fatigued shift-working nurses and midwives compromising patient safety and care; we sought, as a first step to scope the literature with a view to understanding which fatigue reduction/mitigation strategies have been implemented and evaluated in nurses and midwives. As these strategies are often included as sub-elements in more comprehensive Fatigue Risk Management Systems, we feel this is a crucial first step to building an evidence-base for healthcare organisations seeking to address this important operational issue.

This paper addresses the following review questions:

1) What sleep-related/fatigue-management interventions have been assessed in nurses and midwives and what is their evidence-base?

2) What measures are used by researchers to assess intervention effectiveness?

Specifically, we aim to: (i) identify sleep-related/fatigue-management interventions assessed in nurses and midwives by synthesising results from published peer-reviewed research articles; (ii) systematically review all empirical evaluations of fatigue management interventions assessed in nurses and midwives; (iii) identify ways in which researchers have measured effectiveness of these interventions; and (iv) develop a map of interventions and measures in this field.

METHODS

We followed and have reported against the Preferred Reporting Items for Systematic Reviews and Meta-Analyses extension for Scoping Reviews (PRISMA-ScR; Tricco et al., 2018).

Eligibility criteria

Population. We included studies conducted in adults (18+years) where the participants were nurses, midwives or nursing assistants (e.g., health care assistants, nursing associates, enrolled nurses, registered nurses).

Type of intervention. We included studies evaluating any intervention focused on sleep behaviour or fatigue-reduction in nurses.

Comparator(s)/control. We included studies which had assessed an intervention against both passive and active control conditions.

Outcomes. We included studies if they reported effects on fatigue and/or sleep. Provided a study had measured sleep and/or fatigue, we also included measures of work, attention, or cognitive performance as they are related to the impact of shift working on working practices that might be related to patient safety/care. We included studies that had used self-report measures (e.g., questionnaires) and/or physiological measures (e.g., melatonin, body temperature), and/or task-based measures (e.g., reaction time tasks, simulations).

Study design(s). We included all study designs because the scope of our review was very broad. We were interested not only in studies assessing effectiveness but also studies exploring the experience of sleep-related/fatigue-prevention interventions. Therefore, we included both qualitative and quantitative study designs.

Language. Only studies written in English language were eligible for inclusion.

Information sources

Search strategy. The following databases were searched in November, 2018 with no limit on publication dates: MEDLINE, PsychINFO and CINAHL. The following search terms were used: 1) nurses AND 2) sleep AND 3) shift work OR night shift AND 4) fatigue AND 5) biological rhythm OR circadian AND 6) napping AND 7) fatigue intervention. In addition, reference lists of included studies and of other relevant reviews were hand-searched to identify potentially eligible studies.

Study selection. Initial search terms were developed collaboratively between all study authors. Detailed search strategies were developed within the team and the searches were conducted by the second author. Potentially relevant titles and abstracts were downloaded into a reference management database (Mendeley) where duplicates were removed. Abstracts of the remaining articles were assessed by the second author and they were scored as: (1) ‘positive’ (if inclusion criteria were met), (2) negative (if inclusion criteria not met), or (3) as ‘unclear’ (if not enough detail was provided in the abstract to make a decision). Articles scored as ‘positive’ or ‘unclear’ were retrieved for full text review and were reviewed independently by the first and second authors. Where there was debate as to whether or not a study met the inclusion criteria, the studies were discussed with the two other study authors to reach agreement.

Data extraction (selection and coding). Standardised data extraction tables were developed for the scoping review. The first and second authors extracted data from the first five studies into the data extraction table in order to agree format and test all fields were completed. Data from all remaining studies were then extracted into the data extraction tables by the second author and the first author extracted data from a randomly selected sub-sample (n=10) of the remaining articles to ensure reliability and consistency.

Data items. 1) Demographics of study (authors, year of publication, location, study design, participant demographics, study aims, hypotheses [if any]); 2) Intervention characteristics, if applicable (type of intervention, format of delivery, length of intervention, consistency of delivery; and 3) Study characteristics (including study design [qualitative or quantitative and specific designs]), control/other intervention condition/s [if applicable], measurement time points, attrition rate, study outcomes, means and standard deviations, effect sizes of within- and between-group analysis [if applicable], mechanisms of change [if reported], main results/findings and authors conclusions.

Synthesis of results

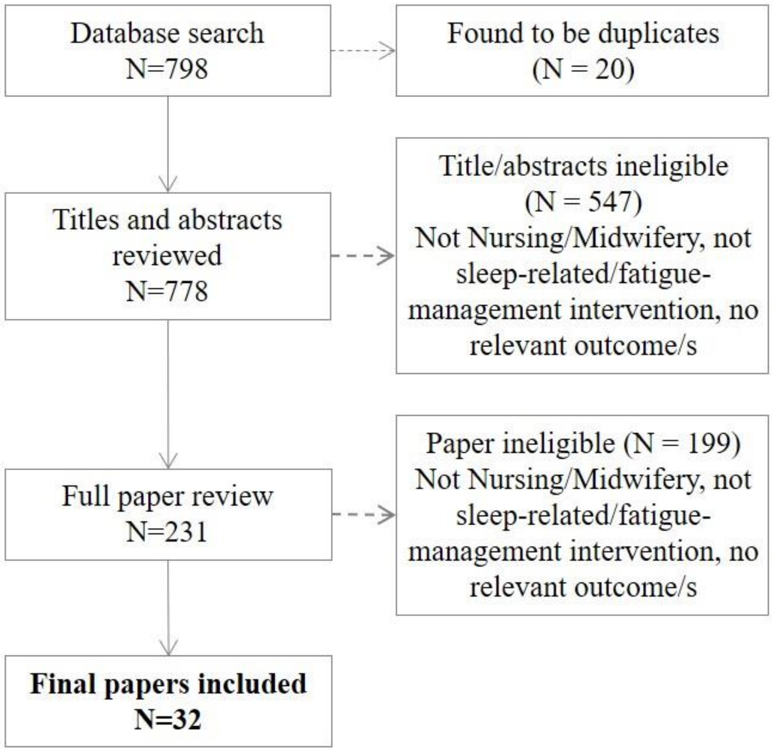
There was a great deal of heterogeneity evident both in terms of the interventions evaluated and the measures used to assess effectiveness of the interventions. Results have been organised according to intervention type with three main categories (1. Napping; 2. Shift patterns; 3. Light exposure/attenuation) and Measures reported under four main categories (1. Sleep/shift work/napping; 2. Fatigue; 3. Biological clock/circadian; and 4. Cognition/attention/performance). We have also described the included studies with reference to study designs and comparators with five main designs: 1. Quasi-experimental; 2. Quasi-survey; 3. Randomised Control Trials; 4. Randomised Trials, with no control group; 5. pre-post studies; and a single qualitative study.

RESULTS

Study selection

The search identified 798 potentially relevant articles. After removal of duplicates, title and abstract review, 231 articles were retrieved for full text assessment. Overall, 32 studies met our eligibility criteria (see Figure 1).

Figure 1. PRISMA flow diagram



Study characteristics

Sample characteristics. Thirty one out of the 32 studies reported the number of participants (except Brown et al., 2016); and all participants were nurses (there were no studies of midwives or which included midwives in their sample). There were a total of 8619 participants, with sample sizes ranging from 5 to 1940. Twenty-five studies reported the mean age of their participants (overall mean = 32.4 years; range 21 – 67 years) and the percentage of female participants (overall percentage = 88.6%; range 55.5% – 100%), with 11 studies conducted in 100% female samples, and nine studies with samples comprised of 80% or more females. Studies were conducted most frequently in USA[3 16 21 25 29], Italy[8 – 11 17], Taiwan[6 7 20 24], France[1 13], Canada[2 26], Brazil[4 27] and Norway[15 18]; with single studies conducted in Australia[5], Belgium[14], Denmark[23], Finland[19], Iran[28], Japan[30], Poland[22], South Korea[32], and Sweden[12]. See Table 1 for a summary of included studies.

Table 1. Study characteristics of included studies

Author/yr *Country*	**N** *%f*	**Aims**	**INT type** *Design*	**Intervention/s**	**Results**	**Comments**
1. Barthe et al. 2015 *France*	16 *100%*	Examined any beneficial effects of napping on sleepiness and quality of work.	Napping *Quasi-exp*	Nap vs. No nap vs. Rest. A nap taken during the night shift, averaging 59 minutes. Data collected over the course of 20 night shifts.	Nurses who napped on shift reported increased sleepiness during the shift. However, towards the end of the shift, they felt less sleepy. Whether the nurses napped did not predict whether nurses were satisfied with the quality of their work.	Results possibly reflect sleep inertia following the on-shift nap. Length of nap should be taken into consideration when planning strategic naps.
2. Boivin et al. 2012 *Canada*	15 *60%*	Assessed the effects of a bright light intervention during the night shift, and dark googles on the commute home, on the endogenous circadian pacemaker.	Light exposure/ attenuation *Quasi-exp*	Light exposure + dark goggles vs. none. Light exposure during the first 6 hours of the night shift using a portable phototherapy lamp + dark goggles on commute home which reduce light transmission to 15%. INT implemented over an average of 12 night shifts.	Those in the bright light intervention group showed longer daytime sleep episodes, and reestablishment of a circadian phase angle observed in day shift workers.	Positive effect of light exposure on circadian biology, however day-to-day benefit cannot be assessed due to lack of fatigue measures/ subjective sleep questionnaires.
3. Brown et al. 2016 *USA*	NR *NR*	A two-hospital napping implementation project which assessed barriers to successful implementation of a night shift nap, and the nap experiences of night shift nurses.	Napping *Cohort*	30-minute nap during the night shift when wanted. A total of 153 naps were recorded over 3-months. Number of participants is not stated but participants completed multiple nap records over the 3-month period.	The data showed that naps are a helpful method of combatting fatigue on the night shift. Moreover, it demonstrated that significant barriers to napping are present, mainly managers being reluctant to allow napping to take place on the night shift.	Demonstrated the positive impact that ad-hoc napping had on fatigue on shift. Investigated the more administrative side of implementing naps, demonstrating that there are still barriers to overcome in terms of making naps a constitutive part of a night shift.
4. Castro-Palermo et al. 2015 *Brazil*	1940 *85%*	Analysed the association between length of nap during the night shift and recovery from night work (fatigue) amongst nurses.	Napping *Quasi-survey*	Nap-NS vs. No nap-NS. Nurses who napped specified the duration of their nap as follows: no nap, nap for up to 2 hours, nap for 2.1-3 hours, or nap for over 3 hours. Groups extracted from survey data.	Results show that napping for 2.1-3 hours on the night shift was associated with the highest recovery after work (reduced fatigue). Nappers overall reported significantly higher recovery after work compared to non-nappers.	The nap durations explored in this study are largely unrealistic, and not biologically supported. Cross-sectional survey study so no causation between variables.

5. Centofanti et al. 2018 *Australia*	130 *88.5%*	Assessed whether napping and caffeine are associated with poor sleep.	Napping Caffeine *Quasi-survey*	Nap-NS vs. Prophylactic napping (before shift); Caffeine on nightshift or morning commute vs. no caffeine. Groups extracted from survey data.	The study found that caffeine reduces total sleep time and is linked to greater sleep disturbances. Nappers were shown to have greater sleep flexibility compared to non-nappers, and reduced total sleep time.	Not only investigated different fatigue interventions used, but highlighted that caffeine may be detrimental, meaning other fatigue interventions need to become more established, such as napping.
6. Chang et al. 2015 *Taiwan*	63 *NR*	Assessed whether implementation of naps in an 8-hr night shift has positive benefits on work performance.	Napping *RT*	Nap-NS vs. No Nap-NS vs. Days shift. Nap for 30 minutes between 2-3am on first night shift.	The nap intervention did not significantly improve subjective sleepiness. However, the nap group had significantly higher information processing. No differences observed in the other cognitive tests.	This study uses a wide range of cognitive tests to tap into the exact mechanisms through which naps may improve performance. Important in the context of patient safety.
7. Chang et al. 2017 *Taiwan*	50 *100%*	Examined the effects of aromatherapy on sleep quality of nurses with monthly rotating night shifts.	Aromatherapy *RCT*	Aromatherapy (Massage + music for 1hr once a week) vs. Control (lay down for 1hr + music once a week)	Aromatherapy group had significantly improved subjective sleep measures, reporting better sleep quality and reduced sleep latency. However, there were no significant differences with objective sleep measures.	Interesting intervention strategy, demonstrating that even taking a non-traditional approach may mitigate some of the negative effects of night shift work.
8. Costa et al. 1993 *Italy*	15 *100%*	Assessed whether bright light exposure mediated tolerance to night shift work.	Light exposure/ attenuation *Quasi-exp*	Baseline (2 days normal light) vs. Light therapy (2 days). Bright light therapy; break room illuminated with iodide lamps.	Exposure to bright light increased subjective energy. There were no significant differences in any other measures.	The intervention was not administered over a sustained period of time. Effects of light therapy are known to be cumulative.
9. Costa et al. 1995 *Italy*	15 *100%*	Assessed whether bright light exposure mediated tolerance to night shift work in a rapidly rotating shift schedule.	Light exposure/ attenuation *Quasi-exp*	Baseline (6 days normal light) vs. Light therapy (2 days). Bright light therapy – break room illuminated with iodide lamps.	Exposure to bright light increased subjective energy. There were no significant differences in any other measures.	Almost identical to the above study with a slightly different shift pattern. Results from the previous study were replicated.
10. Costa et al. 1997 *Italy*	5 *80%*	Evaluated whether exposure to bright light during night shifts facilitates tolerance to working nights.	Light exposure/ attenuation. *Quasi-exp*	Nights (Light therapy via wearable light visors during shift) vs. Nights (no light visors used).	There were no differences with regards to impact to sleep or fatigue for the nights when night visors were not used vs. nights when they were used.	Very small sample size, measures used and data not presented in the paper, other than a few graphs.

11. Costa et al. 2014 *Italy*	294 *NR*	Assessed the impact of three types of rotating shift schedules on nurse's health and wellbeing.	Shift patterns *Quasi-survey*	3 x 8hr (5days) backward rotation with quick returns vs. 3 x 8hr (6days) backward rotation with quick returns vs. 2 x 12hr (5days) forward rotation (all included night shifts). Shift patterns extracted from survey data.	Nurses in the "2x12" rota reported less interference with sleep (duration and quality) than those in the "3x8" rotas. Related to the different direction and intervals between shifts: the "2x12" rota has a forward rotation and 24-hr interval between shifts, whereas the "3x8" rotas have a backward rotation with morning and night shifts in the same day.	Allowed us to which sleeping patterns may be best suited to human physiology.
12. Dahlgren et al. 2016 *Sweden*	1459 *NR*	Compared night work and quick returns, and their impact on sleep and fatigue.	Shift patterns *Quasi-survey*	Frequency of night shifts vs. quick returns. Controlled for quick returns when working nights shifts as wanted to understand impact of nights vs. quick returns alone. Data extracted from survey.	Frequency of quick returns was a significant predictor of poor sleep quality, short sleeps, and exhaustion; with higher frequency predicting more negative outcomes. Frequency of night work did not predict any of the outcomes.	This study presents the argument that time between shifts, rather than night shifts, could be responsible for the negative effects of night shift work in nurses.
13. Daurat & Foret, 2004 *France*	8 *87.5%*	Assessed the impact of napping on self-report and objective sleep outcomes.	Napping *Quasi-exp*	Nap-NS vs. No nap-NS. Nap during the night shift. No set time for nap to be taken. No specified duration of nap to be taken.	Most naps were taken between 04.00-06.00. Nap average was 150mins (shortest 23mins). Those taking longer naps during the night shifts reported less sleep on the subsequent day. Subjective sleep quality worse for non-nappers than napper on days off. Sleepiness significantly higher in nappers after daytime sleep.	Small sample size, no consistency between participants in nap duration.
14. Dirkx, 1993 *Belgium*	78 *100%*	Assessed physiological effects of different patterns of days off and days on duty within a permanent night shift schedule.	Shift patterns *Quasi-exp*	Few night shifts in a row vs. many night shifts in a row.	Those who work many nights in a row have shorter average sleep times than those who work few nights in a row.	In this population, those who worked night shifts had chosen to do so, which may mask some of the effects of night work.

15. Eldevik et al. 2013 *Norway*	1990 *90%*	Assessed if less than 11 hours off work between shifts was related to insomnia, sleepiness, fatigue, and shift work disorder among nurses.	Shift patterns *Quasi-survey*	Quick returns (<11-hrs off between shifts) vs no quick returns. Data extracted from survey.	Quick returns appeared to be associated with excessive sleepiness and insomnia, as well as shift work disorder; indicating that quick returns have a negative impact on health.	Allows us to tease apart not just effects of night work on health, but frequency of night work and effects of short breaks between shifts.
16. Fallis et al. 2011 *USA*	13 *84.6%*	Explored nurses' perceptions, experiences, barriers and safety issues related to napping/not napping during the night shift.	Experience of napping *Qualitative interview*	Experience/s of nap during the night shift. Nurses interviewed to understand their experiences.	Ten nurses napped regularly; two avoided napping because of sleep inertia. The need for and benefits of napping or not during night shift break were linked to patient and nurse safety. Ability to nap affected by the demands of patient care and safety, staffing needs, and organizational and environmental factors. Barriers to napping exist within the organization/work environment.	Focused more on the administrative elements of taking a nap on the night shift, indicating that attitudes towards napping need to be changed in order to be successfully implemented.
17. Ferri et al. 2016 *Italy*	278 *60%*	Assessed whether shift work with nights, compared with day work only is associated with risk factors predisposing nurses to poorer health.	Shift patterns *Quasi-survey*	Rotating shifts (with nights) vs dayshift. Shift pattern groups extracted from survey data.	Rotating night shift work associated with worse sleep and fatigue characteristics, more cardiovascular symptoms such as chest tightness and pain and more psychiatric symptoms.	Looked at a number of physical health measures, not just fatigue. Allowing associations to be made between shift work and overall physical health.
18. Flo et al. 2014 *Norway*	1224 *90.3%*	Investigated whether the number of work shifts with quick returns predicted health problems in nurses at a 1 year follow up.	Shift patterns *Cohort, Longitudinal*	Number of quick returns between shifts – baseline and 12-month follow-up	Quick returns increased the risk of shift work disorders and pathological fatigue over the 1-year follow up period. Reducing the number of quick returns was related to a reduced risk of developing pathological fatigue.	Longitudinal study which helps us assess the change in health status over a period of time.
19. Harma et al. 1998 *Finland*	75 *100%*	Investigated the effects of a physical training intervention on alertness, short-term memory and oral temperature.	Physical activity *Quasi-exp*	Physical activity for 4mths (2-6 training sessions per week depending on fitness) vs. No physical activity.	The intervention appeared to reduce fatigue during the night shift, compared to the control group. No effects on other measures.	An intervention which would provide an array of health benefits, which may offset the health problems associated with shift work.

20. Huang et al. 2013 *Taiwan*	92 *NR*	Is bright light exposure during the first half of the evening/night shift and light attenuation in the morning effective in improving sleep problems in nurses undertaking rotating shift work who suffer from clinical insomnia?	Light exposure/ attenuation *RT*	Bright light during shift + dark goggles on commute home vs. Dark goggles on commute home only. Light exposure for 30 minutes prior to the start of the shift for at least 10 shifts over two weeks; dark goggles on the morning commute.	Participants from the bright light + goggles group reported significant improvements in sleep (reduced insomnia symptoms) when compared with participants in the dark goggles only group immediately after the intervention completed. After treatment 37 nurses (80.4%) from the bright light + goggles group no longer met the criteria for clinical insomnia.	Potential selection bias, however this study provides evidence that light therapy reduces insomnia symptoms, which is generally supported by the literature.
21. Huth et al. 2013 *USA*	378 *96%*	Determined whether there is a relationship between shift timing (day and night) and BMI, and whether BMI has a relationship with sleep quality.	Shift patterns *Quasi-survey*	Night shifts vs. day shifts. Shift patterns extracted from survey data.	Night shift workers reported poorer sleep quality compared to day shift worker. Number of hours per week, not timing of shift, significantly predicted BMI. Raised BMI was also associated with trouble sleeping due to snoring and pain.	Further teases apart the exact aspects of shiftwork which contribute to the negative health symptoms reported in this population.
22. Iskera-Golec et al. 1996 *Poland*	126 *NR*	Compared the health, sleep, psychological, social wellbeing and job satisfaction of nurses working 8-hr or 12-hr shifts.	Shift patterns *Quasi-exp*	8-hr shifts vs. 12-hr shifts (both shift patterns included night shifts).	Nurses working 12-hr shifts showed higher levels of fatigue and emotional exhaustion. There were no significant differences in long term health effects of working different shift work lengths. However, nurses working longer shifts reported lower social and domestic disruption, likely due to having more days off in a row.	The results of this study again suggested that length of time between shifts are important to take into account when looking at the negative health effects of shift work.
23. Jensen et al. 2015 *Denmark*	113 *NR*	Investigated the effect of dynamic light on ICU staff on sleep efficiency, melatonin and sleep quality.	Light exposure/ attenuation *Quasi-exp*	Dynamic light intervention (simulating daylight) installed in ICU ward during night shifts vs. Standard lighting.	Installation of dynamic lighting in the ICU ward resulted in more consolidated sleep, and better rested nurses, compared to standard ward lighting.	Very interesting intervention which could set a precedent for the design of lighting in a hospital ward. This would not only benefit nurses, but also patients.

24. Niu et al. 2012 *Taiwan*	62 *100%*	Investigated the effects of different shift patterns on selective attention.	Shift patterns *RT*	Fixed day shift vs. rotating shifts.	Night shift workers performed significantly worse on attention tasks compared to other shift patterns. This is likely due to Inadequate sleep and a state of somnolence adversely affecting the attention and operation speed of work among night-shift workers.	Impaired selective attention has potential implications on quality of patient care e.g., more errors.
25. Petrov et al. 2014 *USA*	214 *100%*	Determined the off-shift sleep strategies of nightshift nurses, and assessed whether there is a relationship between the sleep strategies and adaptation to shift work.	Napping Sleep strategies *Quasi-survey*	Assessed 5 different sleep strategies for adapting to night shifts (including napping). Different sleep strategies extracted from survey data.	No differences between the different sleep strategies for sleep quality or fatigue. Nap Proxy (1-hr nap during nights) and No Sleep (stay awake for 24-hrs before nights) types were the least adapted (overall) to night-shift work and significantly more likely to be early chronotypes; whereas participants adopting other sleep strategies were more likely to be later chronotypes.	A focus on how chronotype interacts with tolerance to shift work and different strategies used to adapt to shift work. This is quite a complex paper and the shift working adaptations are a little difficult to understand.
26. Rahman et al. 2013 *Canada*	9 *55.5%*	Investigated the effects of filtering short wavelength light during the night shift on sleep and performance characteristics.	Light exposure/ attenuation *Quasi-exp*	Blue light filtering glasses vs. standard indoor lighting on night shifts. Some nurses had blue filtering glasses first and some had standard lighting, then they crossed over. Baseline data (standard lighting) data acts as the control.	Total sleep time significantly longer (40mins). Time to wake up reduced. Sleep efficiency increased. Reaction times and vigilance tasks significantly better. Salivary melatonin increased. No difference for subjective sleepiness. Both day-time and night-time sleep are adversely affected in rotating-shift workers and filtering short wavelengths may be an approach to reduce sleep disruption and improve performance.	Small sample size, but easy to implement intervention.

27. Ribeiro-Silva et al. 2006 *Brazil*	144 *90.9%*	Assessed whether time devoted to daily activities is related to the number of hours worked and to naps taken during the night shift.	Napping *Quasi-exp*	Nap-NS vs. No nap-NS.	Sleeping on the job during the night shift (napping) seems to partially compensate for shorter sleep at home in night workers, through increasing total sleep time. Total sleep time significantly longer for nappers.	An interesting look at how shift work impacts the personal lives of nurses.
28. Sadeghniiat-Haghighi et al. 2008 *Iran*	86 *80.2%*	Evaluated the effects of oral intake of 5mg of melatonin taken 30 minutes before night time sleep to recover from night work.	Melatonin *RCT-crossover*	Melatonin followed by placebo vs. placebo followed by melatonin.	Sleep onset latency significantly reduced while subjects were taking melatonin as compared with both placebo and baseline levels. No evidence that melatonin altered total sleep time.	Melatonin may be an effective treatment for shift workers with difficulty falling asleep when returning to a normal sleep schedule following a night shift. Study supports use of melatonin to adapt to shift work.
29. Smith-Coggins et al. 2006 *USA*	49 *67.3%*	Investigated whether a brief nap during a 12-hour night shift improves cognitive and psychomotor performance.	Napping *RCT*	Nap-NS (40-minute nap at 3am) vs. No nap-NS.	At 7.30am, nap group had fewer performance lapses, reported more vigour, less fatigue, and less sleepiness. They more quickly completed intravenous insertion, exhibited less dangerous driving and displayed fewer behavioural signs of sleepiness during driving simulation. Immediately after nap (4 AM), the subjects scored more poorly on Probed Recall Memory.	First study to look at specific tasks where errors translate into real world mistakes/ errors. A short nap on a night shift may improve reaction time, reduce fatigue, reduce sleepiness and increase vigour at the end of the shift (7:30am).
30. Takahashi et al. 1999 *Japan*	20 *100%*	Examined the effects of a 2-hr nap during a 16-hr night shift on sleepiness and fatigue.	Napping *Cohort*	Nap-NS (2-hr naps during 16-hr night shift).	Compared to pre-nap, sleepiness, fatigue, and dullness increased immediately after napping. Afterwards, sleepiness decreased significantly and other symptoms returned to pre-nap values. Timing of the nap not significant. Post-nap fatigue lasted longer as nap time increased (>1.5hrs).	Unrealistic nap length, moreover naps of this length are not supported biologically, and increase the risk of sleep inertia, which appeared to be a problem in this paper. Nap length should be determined carefully to avoid persistent sleep inertia.

31. Wilkinson et al. 1989 *UK*	16 *100%*	Assessed the alertness of trainee nurses during the night shift - comparing fixed night shifts and rotating shifts.	Shift patterns *Quasi-exp*	Fixed shift (3-mths permanent nights) vs. rotating shifts (including weeks of nights) over three years.	Rotating shifts: Performance fell from first to seventh day of the week on night shift, implying progressive sleep deprivation. Fixed shifts: Performance level fell by the 45th night but had returned to normal by the last (90th) night. In both patterns of work, individuals varied in their ability to sustain performance on nights.	This study suggests that in considering permanent night shifts, careful selection of personnel suited to night work is beneficial.
32. Yoon et al. 2009 *South Korea*	12 *100%*	Determined whether melatonin improves adaption of workers to the night shift, and whether any beneficial effect is enhanced by attenuation of morning sunlight exposure.	Melatonin Light exposure/ attenuation *Quasi-exp*	Oral melatonin alone vs. Oral melatonin + light blocking sunglasses for morning commute home vs. placebo (no melatonin, normal exposure to daylight on commute home).	Nocturnal alertness and performance plus daytime sleep and mood states were assessed during all three treatments. Sleep period and total sleep times were significantly increased by melatonin treatments; yet, nocturnal alertness was only marginally improved. There was no difference between the Melatonin only and the Melatonin + glasses groups.	Another study to support the use of melatonin for adaptation to shift work. This may mitigate some of the long-term negative health effects of night shift work.

f=female; Quasi-exp = quasi-experimental; Quasi-survey = groups determined from survey data; Cohort = pre-post single group; RCT = Randomised Control Trial; RT = Randomised Trial; NS = Night Shift; NR = not reported.

Measures. There was a great deal of heterogeneity evident with regards to measures (see Table 2). Broadly, studies included measures of: Sleep/shift work/napping (20 measures across 27 studies); Fatigue (6 measures across 10 studies); Biological clock/circadian (5 measures across 11 studies); and Cognition/attention/performance (19 measures across 11 studies). The majority of studies used well-validated measures, however six studies[3 4 13 18 27 29] used self-report (sleep/shift work/napping) measures specifically developed for their study. The majority of studies assessing sleep/shift work/napping, fatigue, or biological/circadian factors employed self-report measures, with some studies also using objective measures of sleep/wake (e.g., polysomnography[2 26 29], actigraphy/actiwatches[11 29]), or physiological measures to assess the impact of shift working on circadian rhythms (e.g., salivary melatonin[2 8 9 10 23 26 28], body temperature[2 8 9 10 19]). Studies measuring the impact of shift working on cognition/attention/performance (as proxies for fatigue) tended to use computer-based tasks (see Table 2 for the full list). One study collected experiential data associated with napping and therefore conducted qualitative interviews[16].

Interventions. There was also a great deal of heterogeneity when it came to the interventions/strategies used (see Figure 2). Interventions fell broadly into three categories:

1) 'Napping' (N=11) where the impact of naps (of various durations) on sleep, and/or fatigue, and/or performance was assessed. As Figure 2 shows, studies operationalised nap interventions in a variety of ways, with naps ranging from 30 minutes[3 6] to 3 hours[4] during night shifts. Some participants were able to choose when to nap on shift[1 3 5 25 27 30], whereas others were instructed to nap at a specific time during the shift, for example between 02:00-03:00 h (30 minutes)[6], 03:00-04:00 h (40-minutes)[29], 04:00-06:00 h (no duration specified)[13].

Table 2. Included Sleep/Shift work/Napping, Fatigue, and Biological clock/Circadian measures by study

Measures	Study ID Numbers	Significance/Purpose of Measures
Sleep/shift work/napping measures		Sleep/shift work/napping measures capture a number of sleep characteristics. This allows us to gain an understanding how shift work impairs sleep, and to what extent different shift types impair sleep. Impaired sleep has a number of downstream consequences including impaired cognition, increased fatigue, circadian misalignment and poor physical and mental health. These factors thus may translate into suboptimal patient care.
Karolinska Sleepiness Scale (KSS)	1, 3, 11, 12, 26, 29	
Stanford Sleepiness Scale (SSS)	6	
Epworth Sleepiness Scale (ESS)	15, 18, 26	
Pittsburgh Sleep Quality Index (PSQI)	7, 21, 24[b], 28	
OSA Sleep Inventory	30	
Subjective sleep quality (single item)	11, 14, 23	
Subjective sleepiness VAS	13	
Daily activities Questionnaire[a] (sleep)	27	
Sleep logs / diaries	1, 13, 14, 23, 24, 32	
Polysomnography (objective sleep)	2, 26, 29	.
Actigraphy / actiwatch (objective sleep)	11, 29	
Sleep Disorders Questionnaire[a]	29	
Bergen Insomnia Scale (BIS)	15	
Insomnia Severity Index (ISI)	20	
Nap Experience Questionnaire[a]	3	
Nap Interview[a]	16	
Nap Duration[a]	4, 13	
Shift work and experiences Questionnaire[a]	29	
Standard Shiftwork Index (SSI)	5, 17, 22, 25	
Shiftwork Disorder Scale	15, 18[a]	
Fatigue measures		Higher levels of fatigue may impair cognition, which may translate into more job errors and compromised patient care. Fatigue may also negatively impact overall wellbeing in nurses.
Chalder Fatigue Scale	18	
Fatigue Scale	8, 9, 10, 15	
Fatigue Symptom Questionnaire	30	
Profile of Mood States (Fatigue subscale)	32	
Maslach Burnout Inventory	22	
Need for Recovery Scale	4	
Biological clock / circadian measures		Biological clock/circadian measures allow us to assess phase of the internal biological clock. Chronotype allows us to assess how vulnerable individuals may be to the negative health effects of shift work in terms of the biological clock. Re-aligning the biological clock may mitigate some of the negative health effects associated with shift work.
Biological Clocks Questionnaire	25	
Owl and Lark Questionnaire	29	
Morningness-Eveningness Questionnaire[c]	30	
Salivary melatonin	2, 8, 9, 10, 23, 26, 28	
Core body temperature	2, 8, 9, 10, 19	

[a]Non-validated measure; [b]Chinese version; [c]Japanese version; VAS = Visual Analogue Scale

Table 2. (cont'd) Included Cognition/Attention/Performance measures by study

Measures	Study ID Numbers	Significance/Purpose of Measure
Cognition/attention/performance measures		Cognition/attention/performance measures allow us to assess not only how shift work impacts cognition, but also precisely which aspects of cognition are vulnerable to impairment. This allows us to understand specifically what job-related tasks may become compromised, ultimately impacting the quality of patient care.
Alertness visual analogue scale	19	
Quality of work visual analogue scale	1	
Psychophysical visual analogue scale	8, 9, 10	
Nocturnal visual analogue scale	32	
Degraded Stimulus Continuous Performance test	32	
Unprepared Simple Reaction Timer task	31	
Psychomotor Vigilance task	29	
Probed Recall Memory task	29	
Catheter simulation task	29	
Driving simulation task	29	
d2 Selective Attention Task	24	
Go / No Go Task	26	
Search and Memory Test	8, 9, 10, 19	
Wisconsin Card Sorting Task	6	
Digit Substitution Test	6	
Symbol Searching Test	6	
Taiwan University Attention Test	6	
Task Load Index	8, 9, 10	
Auditory Reaction Time	8, 9, 10	
Other measures		
Caffeine consumption	5	

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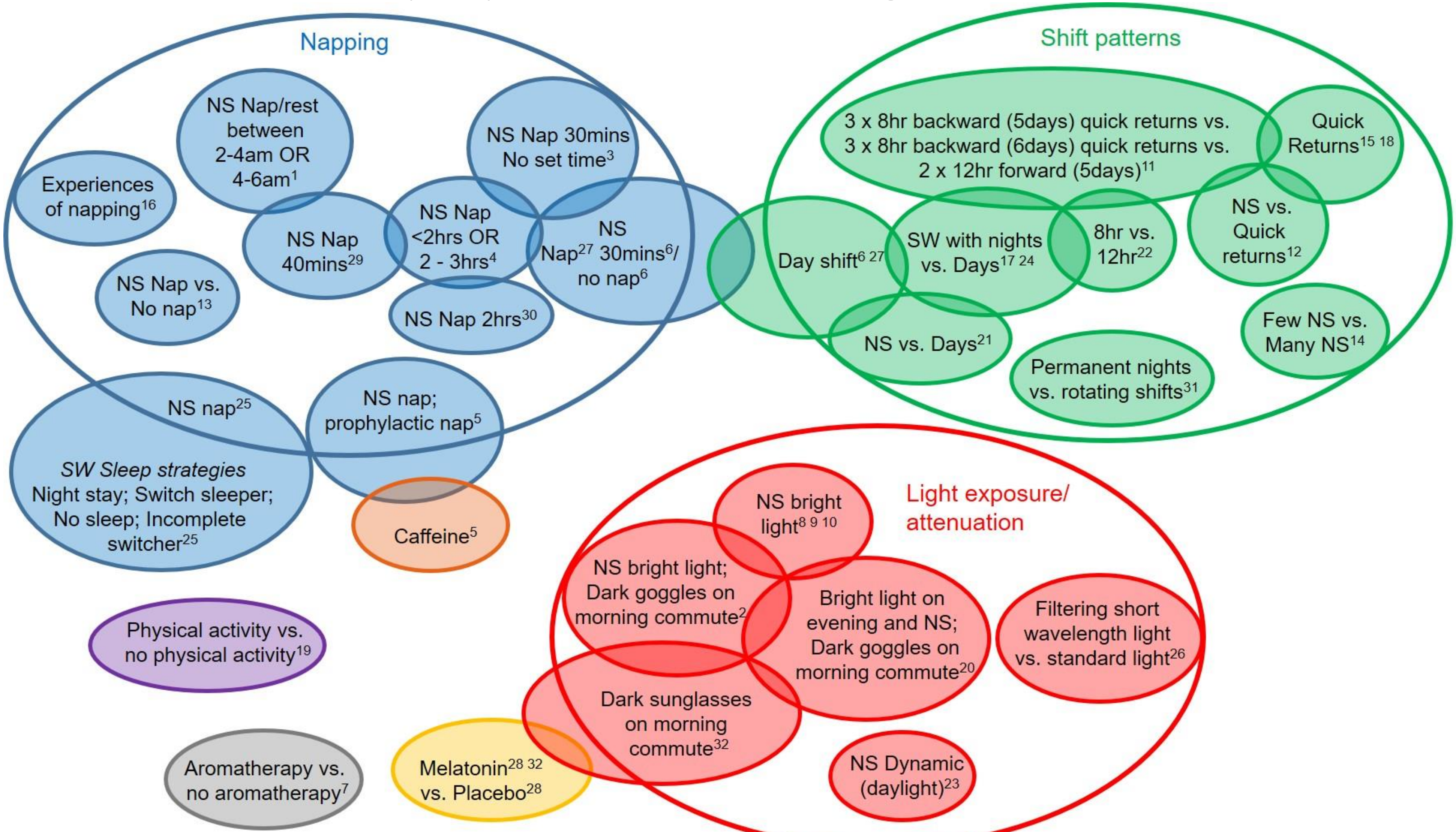
Figure 2. Sleep-related/Fatigue-management interventions map: study interventions categorised by type of intervention



NS = Night shift; SW = Shift work

Overlapping circles denote similarities between interventions (within-category), or studies where two different categories of interventions were evaluated (between-category)

2) ‘Shift patterns’ (N=10) where different shift patterns were assessed against each other for their impact on outcomes related to sleep and/or fatigue and/or performance. Some studies assessed fixed shift patterns (permanent nights[31]; permanent days[24]) against rotating shift patterns; others assessed the difference between working night shifts and day shifts[17 21]; some studies evaluated the impact of frequency of consecutive night shifts[12 14]; others assessed the impact of quick returns (i.e., limited time between shifts)[12 15 18]; one study assessed 8-h and 12-h shifts against each other[22]; and the final study assessed three different shift patterns (all including night shifts), against each other[11].

3) ‘Light exposure/attenuation’ (N=8) where the participants’ exposure to light during the night shift and/or in the morning when commuting home was manipulated to investigate its impact on sleep and fatigue, or on other factors related to shift work adaptation. The majority of studies assessed some form of bright light therapy during the night shifts. Some studies exposed their participants to bright light: during the 30 minutes immediately before the shift[20] or for the first 6 hours on shift[2], in the break room[8 9], via wearable light visors[10], or by simulating daylight conditions[23]. One study had their participants wear blue light filtering glasses during the night shift[26], and two studies – alongside their bright light therapy, required participants to also wear dark goggles on their morning commute home[2 20]. The final study assessed dark sunglasses on the morning commute against melatonin[32].

In addition to the three main categories, other interventions assessed included: physical activity[19], aromatherapy[7], melatonin[28 32], caffeine[5], and alternative sleep strategies[25].

Study designs and comparators. There were five main study designs employed. 1) Quasi-experimental, with non-randomised conditions assessed against each other (N=14): six evaluated light exposure and/or light attenuation interventions[2 8 9 10 23 26]; three assessed the impact of napping[1 13 27]; three evaluated different shift patterns against each other[14 22 31]; one evaluated the impact of physical activity[19]; and the final study evaluated melatonin[32]. 2)

Quasi-survey, in which groups or conditions were extracted through survey data and then differences between groups assessed (N=8): five assessed the impact of different shift patterns[11 12 15 17 21]; and the remaining three studies assessed the effect of naps on the night shift[4 5 25], caffeine during the night shift[5], and other sleep strategies[25]. 3) Randomised Control Trials (N=3): one study evaluated the impact of napping[29], one study evaluated melatonin[28], and one study evaluated aromatherapy massage[7]. 4) Randomised Trials, with no control group (N=3): one study assessed napping[6], one study assessed shift patterns against each other[24], and the final study assessed the impact of light exposure/attentuation[20]. 5) Pre-post studies (N=3): two studies assessed the impact of napping[3 30], and one study evaluated the impact of quick returns (less than 11 hours off between shifts)[18]. One study was qualitative, interviewing participants about their experience of napping[16]. See Table 1 for a full summary of all included interventions and the comparators.

Synthesis of results

Interventions in this literature were clustered under three main approaches (Figure 2) and were evaluated against various outcomes associated with inadequate shift work adaptation (e.g., fatigue, sleep disturbance, performance decrements at work). Firstly, ‘sleep/napping’ interventions were designed to evaluate the impact of manipulating sleep either during the shift (napping) or before/after shift (prophylactic sleep). Secondly, the impact of working different shift patterns (e.g., nights versus days) or the impact of ‘quick returns’ (less than 11 hours between shifts) or the impact of the organisation of blocks of shift patterns (e.g., 8-h vs. 12-h rotating shifts; ‘12-h forward rotating’ vs. ‘8-h backward rotating’) was assessed. Finally, studies evaluated the impact of bright light exposure and/or light attenuation, for example, by changing the lighting in certain ward areas on night shift and/or requiring staff to wear dark goggles/sunglasses on their morning commute home.

Impact of napping interventions. Just as the heterogeneity was evident in the ways in which napping interventions were operationalised, there was a lack of consistency in measures used across studies and in the results.

For the studies that used measures associated with sleep quality, there was wide variation in results, potentially depending on nap timing and duration. Some studies reported that sleepiness increased immediately after napping for 1 hour[1] or 2 hours[30], with reduced sleepiness 2 hours later (after a 2-h nap)[30] or at the end of the night shift after a 1-h nap[1] or 40 minute nap[29]; whereas other studies reported no impact on sleepiness during shift after a 30 minute nap[6], or increased sleepiness after sleep during the following day[13]. One study reported that total sleep time was longer for nappers when compared with non-nappers[27], however, another study reported the opposite[5].

In the studies that evaluated fatigue as an outcome: some studies found reduced fatigue after napping for 30 minutes[3], 40 minutes[29], or 2-3 hours[4] on night shift, whereas other studies found no impact of napping on fatigue[25], and one study found that fatigue was initially worsened but then returned to pre-nap levels within 2 hours of the end of the 2-h nap[30].

In terms of studies that assessed measures associated with performance at work, information processing was improved (immediately after a 30-minute nap)[6], as was performance on vigilance and simulation tasks (at the end of the shift) after a 40-minute nap[29]. However, participants did poorly on a memory recall task (immediately after a 40-minute nap)[29], and there was also no effect on cognitive performance or attention tasks after a 30-minute nap[6]. Two studies considered barriers to napping during work hours citing lack of manager support[3 16], poor staffing levels[16], and concern over patient care and safety[16].

Impact of shift patterns. The impact of night shifts was assessed by rotating shift patterns (including nights)[11 17 24], or fixed nights[21 31] against day shifts; with some other studies evaluating different rotating shift patterns against each other, for example 8-h vs 12-h rotating shifts[22], or ‘two x 12-h (forward rotating)’ rota against two different ‘three x 8-h (backward rotating)’ rotas[11]. These studies found that shift patterns including night shifts were associated with poorer sleep quality[14 17 21] and increased fatigue[2 17], with longer shift patterns being more problematic. One study found that frequency of nights (i.e., more consecutive night shifts) predicted poorer sleep[14]. Some studies evaluated the impact of quick returns between shifts (<11-h)[12 15 18] and found higher levels of fatigue[12 18], poorer sleep quality[12], increased sleepiness[15]; and increased risk of shift work disorder[15 18] and insomnia[15]. One study considered fixed nights (3-months) against a rotating shift pattern (including 3-week blocks of nights) over a year and concluded that performance decrements were evident in both patterns[31].

Impact of light exposure/attenuation. Four of the studies assessed light exposure interventions alone[8 9 10 23] and found that self-reported energy levels on shift increased with exposure to bright light[8 9], sleep quality increased and fatigue was reduced with exposure to dynamic lighting (simulating daylight)[23]; however, one study found no effect of their light visor intervention on sleep or fatigue[10]. The two studies assessing bright light exposure during the night shift and dark goggles on the commute home found that daytime sleep duration increased, circadian adaptation was promoted[2], and that sleep improved resulting in decreased insomnia[20]. Filtering blue light wavelengths during night shifts had a number of positive effects including increased reaction times and performance on vigilance tasks during night shifts, and increased total sleep time and faster wake-up times on non-work days[26]. The remaining study assessed light blocking glasses on the morning commute but found no effect on daytime total sleep duration[32].

Impact of other interventions. Two studies assessed oral melatonin and found reduced sleep onset latency on night time sleep[28], and increased sleep duration and total sleep time on daytime sleep after night shifts[32]. One study assessed caffeine consumed either on the night shift or during the morning commute home and found that participants reported reduced total sleep time and increased sleep disturbance[5]. A physical activity intervention (2-6 training sessions a week over 4-months) reduced self-reported fatigue[19]; and an aromatherapy massage plus music (1-h a week for a month) improved subjective sleep quality and duration, but did not impact objective sleep measures[7].

Summary and quality assessment

The heterogeneity in sleep-related/fatigue-management interventions and measures used to assess effectiveness in the studies in this review reflects a piecemeal approach to fatigue management in healthcare. The interventions evaluated did not form part of comprehensive Fatigue Risk Management Systems and instead were standalone interventions in specific, and often small, samples of nurses. Over half of the studies assessing the impact of different shift patterns on outcomes related to sleep/fatigue/work-based performance employed cross-sectional surveys designs; and even though we included these studies in our review, they did not test an 'intervention' *per se*. Nonetheless, shift working practice is an important consideration in managing fatigue in healthcare staff, and in reality it is difficult to design and run studies where shift patterns are manipulated in real time. The studies evaluating light exposure/attenuation interventions were predominantly conducted in small samples raising questions about the representativeness of these samples and the generalisability of these results.

DISCUSSION

We conducted this scoping review to: (i) identify sleep-related/fatigue-management interventions assessed in nurses and midwives; (ii) systematically review all empirical evaluations of fatigue management interventions assessed in nurses and midwives; (iii) identify ways in which researchers have measured effectiveness of these interventions; and

(iv) develop a map of interventions and measures in this field. In spite of our aim to evaluate literature about sleep-related/fatigue-management interventions in nurses and midwives, we did not find any studies conducted in samples of midwives. We were also surprised that none of the studies had been conducted in the UK, with most studies conducted in the US (N=6), Italy (N=5), and Taiwan (N=4).

One of our most striking findings was that there was tremendous heterogeneity not only in the interventions evaluated but also in the measures employed to assess their effects. Interventions evaluated fell broadly into three main categories - 1) napping; 2) shift patterns; and 3) light exposure/attenuation – however, even within each of these categories there was heterogeneity evident with, for example, 'napping' being operationalised in a variety of ways. Likewise, with regards to the measures, which were categorised under four main topic areas (1. sleep/shift work/napping; 2. fatigue; 3. biological clock/circadian; 4. cognitive/attention/performance), there was also heterogeneity evident within each of these categories. There appears to be very little cohesion in this literature around how to intervene to improve sleep and/or reduce fatigue in shift working in nurses and midwives, and then how to evaluate the effectiveness of these interventions. This does not suggest that each of the approaches taken is not valid and in fact, the heterogeneity means that researchers are approaching the problem of shift working (and how to solve this) in different and interesting ways; however, it does make it challenging to develop a best-evidence approach to tackling the problem. Given that shift working in nurses and midwives not only negatively impacts on their health (e.g., Colditz et al., 2016; Gu et al., 2015) but also may compromise patient safety and care (Dorrian et al., 2006; Gold et al., 1992; Kunert et al., 2007), it is important to develop the evidence-base further in order to properly advise healthcare services, and as a first step to identifying fatigue reduction and mitigation strategies which could be included in more comprehensive Fatigue Risk Management Systems.

Napping as a fatigue-management intervention

Napping, on the face of it, would appear to be a relatively easy intervention to implement in health settings; however, a great deal of thought needs to be given to the duration and timing of naps during night shifts. In our review, (in general) longer naps were associated with poorer sleep (e.g., the next day) and performance; however, not all studies reported nap length and there was variation evident with some studies suggesting shorter naps (e.g., 30 minutes) were just as effective as longer naps (e.g., 2 hours) with respect to sleep quality, fatigue and performance at work. Other researchers have highlighted this inconsistency with regards to napping effectiveness in quantitative studies (e.g., see Wendsche, Ghadiri, Bengsch, & Wegge, 2017) and qualitative research is also in accordance with some studies revealing beneficial and unfavourable effects **(**Edwards, McMillan, Fallis, 2013; Fallis, McMillan, Edwards, 2011). Some of the nap durations (e.g., 2-3 hours) in the included studies would be highly impractical as an intervention in acute health services where staff shortages and concerns about patient care/safety exist. Moreover, the sleep science literature would suggest that napping for too long is sub-optimal because it is more likely to increase sleep inertia post-nap compromising performance (Driskell, & Mullen, 2005). To optimise the benefits of napping, an individual's circadian phase should also be considered when determining timing of naps, for ease of falling asleep. Sleep tendency is highest in the early hours of the morning (02:00h – 05:00h) before a person's core body temperature starts to rise in preparation for waking (Fisk et al., 2018), therefore initiating and maintaining good quality naps at this time could be more achievable.

Even though napping would appear to be a relatively easy fatigue-management approach, two studies in our review highlighted barriers to napping during shifts citing lack of manager support, poor staffing levels, and concern over patient care and safety (Brown et al., 2016; Fallis et al., 2011). These findings are supported by those of other published studies. For example, Edwards et al. (2013) assessed experiences and attitudes to napping in 47 highly experienced critical care nurse managers in Canadian hospitals (most of whom had worked night shifts) with barriers including: no written policies on napping at an organisational level (driving uncertainty about whether or not there would be organisational support); lack of suitable napping space for staff; concerns about inadequate staff coverage with extended breaks needed for napping; patients' family concerns about nurses napping and impact on patient care; covering staff not being proactive enough with patients; and that nurses would have difficulty waking from naps and would perform more poorly for some time after breaks (e.g., if awakened to an emergent event). Geiger-Brown et al. (2016) attempted to implement a 30-minute napping intervention in 6 different nursing wards across two hospitals in the US, with only one ward successful in doing so. The barriers reported were similar to those reported by Edwards et al. and included: lack of support from the nurse manager (with the intervention being blocked without discussion with ward staff); concerns about the feasibility of napping on 'busy' wards requiring rapid response from staff; lack of suitable space for staff to take naps; concerns about impact to nursing care; and stigma associated with taking naps despite reassurances that it was acceptable and would be helpful.

Given that none of the studies included in our review were conducted in the UK, we do not know if these findings from Canada and the US are generalisable to the UK, or if the same challenges would be present. This represents a clear avenue for future empirical work.

Organisation of shift work and environmental changes

Shift work including nights and longer shift patterns appeared to have negative impacts on sleep and resulted in increased levels of fatigue. In particular, 'quick returns' (less than 11 hours) between shifts had multiple negative consequences, and increased numbers of consecutive night shifts were associated with compromised sleep. Our findings align with those of previous studies evaluating the impact of shift working on sleep and fatigue in nurses with multiple studies suggesting rotating shift patterns (which include nights) being more detrimental than patterns of shifts with blocks of nights alone (e.g., Gold et al., 1992); and that shift patterns including ‘quick returns’ have negative fatigue-related consequences such as increased risk of medication errors (Rogers, 2008) and patient mortality (Trinkoff et al., 2011). Given that healthcare settings require 24/7 working, shift work is unavoidable for nurses and midwives; however, the results here suggest that some shift work patterns are more detrimental for sleep and performance and generate more fatigue than others. Therefore, healthcare organisations could consider these findings when organising staff rotas including night shifts. The increased propensity for internal rotation (everyone doing night and day shifts) and for quick returns in the UK represents an important area for attention.

Appropriately timed exposure to bright light, blue light filtering glasses and dark goggles/sunglasses on the morning commute all appeared to have promise. These interventions could be easily implemented in healthcare organisations and are simple for staff to adopt, with some interventions (e.g., lights installed in ward environments) requiring no effort on the part of nurses and midwives. However, exposure to bright light needs to be carefully timed in the early part of the night shift, and avoidance of light at the end of the night shift on the commute home (through use of sunglasses for example); and effectiveness of lights installed in ward environments depends on intensity, wavelength and timing. There was also evidence of variation in effectiveness for some of the wearable interventions (e.g., light visors). Therefore, careful consideration of the evidence-base is needed before organisations invest in these types of interventions; and any policy or guidance documentation would need adequate detail to implement these interventions appropriately.

Melatonin, appropriately timed, has promise and is easy to administer with minimal side-effects; however, whilst it is freely available in some countries (notably the USA), in the UK it is only available on prescription as a slow-release preparation for poor sleep quality in patients aged over 55 years. While the effectiveness of fast-release melatonin as a "chronobiotic" to shift the timing of the circadian system is well demonstrated (Arendt & Skene, 2005), the effectiveness of slow-release melatonin in shift work remains to be assessed. Caffeine appeared to have detrimental effects negatively impacting sleep; however, this was only assessed in one study in our review. The studies evaluating physical activity (Harma, Ilmarinen, Knauth, Rutenfranz, & Hanninen, 1998) and aromatherapy (Chang, Lin, & Chang, 2017) interventions would need replication in order to assess the reliability of the findings and neither is easy to implement.

Strengths and limitations

This is the first review to consider sleep-related/fatigue-management interventions for fatigue-related outcomes in nurses and midwives. We conducted a comprehensive and systematic search and have delivered an international perspective of this important topic. We used rigorous and transparent methods throughout the entire process. It was guided by a protocol reviewed by a research team with expertise in knowledge synthesis and scoping reviews. To ensure a broad search of the literature, the search strategy included three electronic bibliographic databases. Each article was reviewed by two independent reviewers who met in regular intervals to resolve conflicts. Our use of a bibliographic manager (Mendeley) ensured that all citations and articles were properly accounted for during the process. Limiting our search to English language articles may mean that we have missed some studies in this area.

Implications for research

Despite the broad inclusion criteria in our review, we did not find any studies that had been conducted in the UK, nor studies that included midwives. While nurses and midwives share similar challenges when it comes to the impact of shift working, they do not perform the same roles; therefore, future empirical work including midwives is warranted. Overall, sleep and circadian science knowledge has not been well applied to nursing and midwifery sleep/fatigue/shift work questions; comparatively, other safety critical industries are ahead of the curve (e.g., aviation, transport, manufacturing). Therefore, future research programmes in this area should include representation from experts in the sleep/circadian science field.

Addressing fatigue in nursing to support the provision of high-quality care and a healthy workforce relies on comprehensive fatigue reduction programmes, similar to the Fatigue Risk Management Systems that have been developed in other industries, such as transportation, aviation, and the military (Steege et al., 2017). However, in the UK and elsewhere further empirical work is needed to understand the current landscape with regards to organisation-specific policies which may already be in place in healthcare organisations. We also need to explore knowledge of, and attitudes to, different fatigue-reduction policies and approaches within the NHS and wider international healthcare systems. This will help us to uncover barriers and facilitators to the development and implementation of more comprehensive Fatigue Risk Management Systems for nurses and midwives.

Conclusions

The literature related to sleep-related/fatigue-management interventions for nurses and midwives is fragmented and lacks cohesion. Our review suggests that napping could be beneficial but there was wide variation regarding nap duration and timing, and we need to understand more about barriers to implementation. Longer shifts, shift patterns including nights, and inadequate recovery time between shifts (quick returns) were associated with poorer sleep, increased sleepiness and increased levels of fatigue. Light exposure/attenuation interventions showed promise but the literature was dominated by small, perhaps unrepresentative samples. Further empirical work is warranted with a view to developing comprehensive Fatigue Risk Management Systems in healthcare to protect against fatigue in nurses and midwives.

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