Nurses, sleep disturbances, desynchronization of circadian rhythms, and performance: a dangerous liaison? A narrative mini-review

R. CAPPADONA[1,2,3,4], A. DE GIORGI[2], B. BOARI[2], R. TISEO[2], P.J. LOPEZ-SOTO[3,4,5], F. FABBIAN[1,2,3,4], R. MANFREDINI[1,2,3,4]

[1]Department of Medical Sciences, University of Ferrara, Ferrara, Italy
[2]Azienda Ospedaliero-Universitaria 'S. Anna, Ferrara, Italy
[3]Department of Nursing, Maimonides Biomedical Research Institute of Cordoba, Spain
[4]University of Cordoba, Spain
[5]Hospital Universitario Reina Sofia de Córdoba, Spain

Rosaria Cappadona and Alfredo De Giorgi contributed equally to this work

Abstract. – OBJECTIVE: Nursing is a high-stress occupation, and recent research of circadian rhythm desynchronization has focused on its consequences for nurses' health. Moreover, shift-work, sleep disturbances, nightmares, and health issues are closely related to individual circadian preferences ('chronotype'). The aim of this narrative mini-review was to check the available literature to collect findings on the interrelationships among these aspects, as well as to determine the possible consequences for performance.

MATERIALS AND METHODS: We explored the PubMed, EMBASE and Google Scholar electronic databases using the search terms 'Nursing', 'Stress', 'Sleep disturbances', 'Nightmares', 'Circadian rhythm', 'Desynchronization', 'Chronotype', 'Performance', and 'Sex/Gender'. Due to the wide heterogeneity of studies, with most including only some of these terms, we proceeded to single data extractions after analyzing the studies case by case and decided to conduct a narrative mini-review.

RESULTS: Shift work, due to the regular alterations of the daily light profile, disrupts the normal circadian sleep-wake cycle and is associated with impaired health among rotational shift workers, with nurses on the frontline. Circadian desynchronization may be associated with adverse effects on nurses' health and may be a risk factor for stress, metabolic disorders, and sleep disturbances, including nightmares, and stress operates in a bidirectional fashion. Chronotype plays a crucial role as well, since the asynchrony between one's chronotype and social working hours (social jetlag) may generate problems, since the time-of-day and optimal performance are strongly connected.

CONCLUSIONS: Circadian rhythms, chronotype, sleep, health, and working performance are strongly connected. The assessment of chronotype could represent a tool to identify health care personnel at higher risk of circadian disruption, allowing for mitigation of work-related stress and sleep disturbances, and reducing the risk of making working errors.
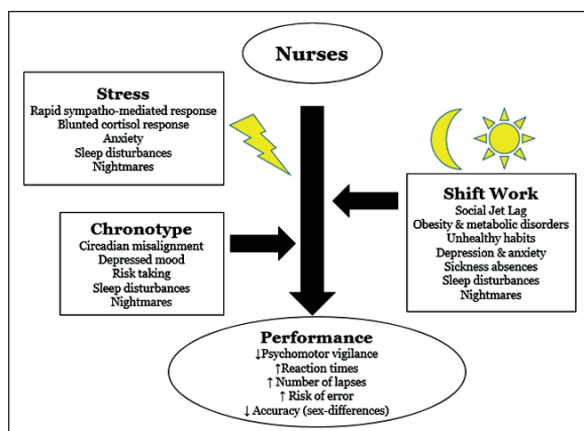
Key Words:
  Nursing, Stress, Sleep disturbances, Nightmares, Circadian rhythm, Desynchronization, Chronotype, Performance, Sex/Gender.
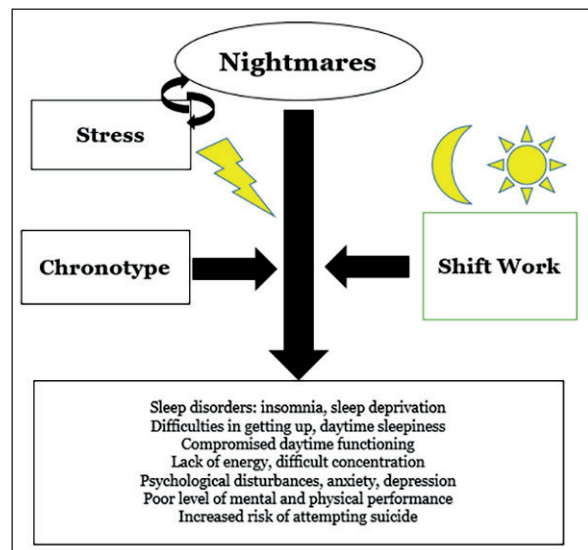
Introduction

Stress has been considered an occupational hazard since the mid-1950s[1], and nursing represents a high-stress condition due to the classical four sources of anxiety: patient care, decision-making, taking responsibility, and change[2]. A couple of decades later, Freudenberger[3] coined the term "burnout" to describe workers' reactions to the chronic stress common in occupations involving numerous direct interactions with people. Burnout refers to a constellation of feelings of exhaustion, depersonalization, and a low sense of personal accomplishment that develops secondary to long-term occupational stress[4]. It has been explored work stress among health care personnel in different settings and countries, with most of them focusing on nurses[4]. A recent systematic review[5] found that midwives are exposed to moderate levels of emotional exhaustion and low levels of personal accomplishment, although midwives with less than ten years of experience were more vulnerable to burnout than those with ten years or more.

Corresponding Author: Fabio Fabbian, MD, Ph.D; e-mail: f.fabbian@ospfe.it

Living organisms try to maintain biological homeostasis during environmental or physiological challenges and protect against internal or external stress by using several mechanisms, e.g., the hypothalamic-pituitary-adrenal (HPA) axis, the sympatho-adrenomedullary system (SAM), and the cardiovascular, metabolic, and immune systems[6]. Exposure to psychological stressors activates two different pathways, and the final result includes either rapid SAM-mediated reactions[7] or delayed responses mediated by the HPA axis[8]. Significant correlations between nightmares and high levels of anxiety and stress have been reported for university students[9] and stockbrokers[10]. Moreover, individuals with frequent nightmares could have a reduced physiological adaptability to stressors, since a blunted cortisol awakening response has been found in working women[8]. Thus, given the high stress level of nurses, the present minireview aimed to verify, by consulting the literature, the possible relationship between sleep disturbances, including nightmares, circadian rhythm desynchronization, chronotype, nursing activity and working performance, and even sexual activity (Figures 1 and 2). We explored the PubMed, EMBASE and Google Scholar electronic databases using the search terms 'Nursing', 'Stress', 'Sleep disturbances', 'Nightmares', 'Circadian rhythm', 'Desynchronization', 'Chronotype', 'Performance', and 'Sex/Gender'. Due to the extreme heterogeneity of the studies, with most addressing only some of these topics, we proceeded to single data extractions and analyzed the studies case by case, and only a narrative mini-review was possible.

Figure 2. The multifaceted relationship between nightmares and physical and psychological health.

Sleep Disturbances and Nightmares

Sleep disorders are common across a woman's lifespan, and women report more sleep difficulties and insomnia than men[11]. In addition to a higher frequency of sleep disorders in women, a series of sex-related differences for many sleep and dreaming items exist, such as dream content and recall, self-reported dream perspective, sharing dreams, lucid dreaming, and daydreaming[12]. Another consequence of poor sleep quality in women is its association with sexual dysfunction. Data from a recent study[13] by the Mayo Clinic, USA, on more than 3,400 subjects found that women with poor sleep quality were 1.5 times more likely to report female sexual dysfunction ($p<0.001$), and sexually active women were more likely to report good sleep quality than sexually inactive women (25% *vs.* 21%, $p=0.003$)[13].

Parasomnias, and nightmares in particular, are severe sleep disorders. Parasomnias represent a group of sleep disorders characterized by abnormal, unpleasant, motor, verbal or behavioral events that occur during sleep or wake-to-sleep transitions. They can be observed during both rapid eye movement (REM) and nonrapid eye movement (NREM) sleep states, with a lifetime prevalence in adults of approximately 66%[14]. Nightmare is defined as an "extended, extremely dysphoric" dream that "usually involves efforts to avoid threats to survival, security, or physical integrity"[15,16]. The prevalent emotion is fear, although other emotions such as anger, shame and

Figure 1. The complex relationship between nursing activity and working performance.

sadness may be reported. Nevertheless, contrary to night terrors that exhibit confusional arousals, incomplete awakenings and difficulties in being comforted, individuals with nightmare disorder usually wake up completely, orient immediately and remember the dream vividly[17]. Frequent nightmares are associated with several mental complaints, sleep disruptions and insomnia, as well as with compromised daytime functioning and tiredness upon getting up[17]. Moreover, daytime sleepiness, lack of energy, difficulties in concentrating, worries about insufficient sleep, increased mental distress, anxiety, depression, poor performance, maladaptive personality functioning, and even increased risk of attempting suicide have been reported[17]. In addition, nightmares, by causing further stress and perpetuating the psychopathology, could progress to the point of becoming a chronic sleep disorder[18].

Similar to other sleep disorders, nightmares are more common in women. A meta-analysis study[19] demonstrated a gender difference in nightmare frequency; i.e., women tended to report nightmares more often than men, although this gender difference was only found in adolescents and young and middle-aged adults but not in children or older persons[19]. The results from a Japanese study[18] on high school students found that the incidences of nightmares among junior and senior high school students were 28% and 7%, respectively. Significant predictive factors for the onset of nightmares, among others, were poor subjective sleep quality (OR 1.60, $p=0.010$) and female sex (OR 1.82, $p<0.001$)[18].

The majority of nurses are women, and they may experience frequent nightmares due to their stressful work, and nightmares and stress occur in a bidirectional fashion. The bidirectional association between stress severity and nightmares was studied in a sample of approximately 400 nurses (92% women), 47% of whom reported in a diary at least one nightmare across two weeks[20]. Days with greater stress were associated with higher odds of experiencing a nightmare (OR=1.22, $p=0.001$), as well as a greater nightmare severity ($p=0.033$), and a nightmare occurrence was associated with greater next-day stress severity ($p<0.001$)[20].

The recent COVID-19 pandemic, due to the impressive burden of stress placed on health workers, caused an increase in sleep disturbances and nightmares. A Chinese study[21] of more than 500 health care workers engaged in Wuhan during the coronavirus 2019 outbreak (114

doctors, 414 nurses) found that 27% of subjects reported frequent nightmares[21]. Reduced sleep duration and reduced sleep efficiency were independently associated with frequent nightmares (OR=1.96 and OR=2.17, $p=0.029$ and $p=0.027$, respectively), and subjects with both reduced sleep duration and sleep efficiency were also associated with frequent nightmares (OR=2.70, $p<0.001$)[21]. The Nightmare Disorder Index (NDI), an efficient and valid tool for self-assessment of nightmare disorders, could be recommended for nightmare screening, particularly for high-risk populations such as health care workers[22].

Circadian Rhythms, Chronotype, and Desynchronization

Circadian rhythms represent ubiquitous biological oscillations of approximately 24 h periods that are present and conserved in all living organisms. The daily timekeeping system is called "circadian" from the Latin "*circa diem*," which means "approximately a day," derived from the duration of a cycle of Earth rotation[6]. This system is both autonomous and self-sustainable, based on cell autonomous, transcriptionally based, molecular mechanisms, named circadian clocks but also continuously entrained by external time cues (called "synchronizers")[23]. The endogenous circadian system confers a selective advantage of anticipation to living organisms, enabling them to prepare and respond to environmental factors in a temporally appropriate manner[6]. Thus, these circadian rhythms also prepare the cardiovascular system for optimal function to match the daily anticipated behavioral and environmental cycles, including variable activities when awake during the day and recuperation when sleeping at night[24].

In humans and other mammals, many physiological processes are affected by circadian rhythms, but individual and gender differences exist, roughly summarized under the concept of morningness/eveningness[25]. Horne and Ostberg[26] first published a self-assessment questionnaire to evaluate individual differences in circadian attitudes, categorizing people as evening-type (E-type), morning-type (M-type), and neither-type or intermediate (I-type)[26]. Individual differences in chronotype, or in other words, the individual's preference for the timing of daily activities, are associated with markers of circadian physiology such as the peak, amplitude, or period of core body temperature, melatonin, and cortisol[6,27,28]. Individual chronotypes also exhibit differences by sex and age. Men are on average

more evening-oriented than women, but these sex differences decrease with time: young women are more morning-oriented than young men, but older women are less morning-oriented than older men[29]. Chronotype may be associated with general health issues. Findings of a review by Fabbian et al[30] reported that E-type is more likely to be associated with unhealthy dietary habits, smoking, alcohol drinking (in younger people), diabetes and metabolic syndrome, psychopathological issues, and reduced school performance. The eveningness influence over psychological issues may also be gender-specific, and female E-types report less positive affect after the morning wake-up than female M-types[31]. In contrast, men do not show such a relationship[31]. Sex/gender differences have also been found for risk-taking, a complex form of decision-making that involves a calculated assessment of potential costs and rewards, immediate or delayed. Although men show a higher propensity for risk-taking, E-type women take significantly more risks than I-type and M-type women[32].

While homeostasis with the environment ensures a regular rhythm in biological pathways, 'modern' perturbations have been shown to alter rhythmic patterns. Light is the strongest synchronizer of the human circadian timing system, and the discovery of electric light and the consequent possibility of artificial lighting opened up the era of shiftwork and night work. Moreover, the possibility of rapid air travel across several time zones exposes the traveler to a shift in the internal biological clock, with transient rhythm desynchronization, which lasts until the biological rhythms adjust to the new environmental conditions[33]. In particular, eastward flights (phase advance) take longer to re-entrain the circadian clock than westward flights (phase delay)[33]. A growing body of evidence has also shown that daylight saving time (DST) is a cause of rhythm desynchronization. In fact, quite similar to jet lag, DST produces a temporary misalignment of the endogenous circadian clock, and the spring DST shift (phase advance) is likely to disrupt circadian rhythms more than the autumn DST (phase delay)[34]. Transitions into and out of DST may lead to sleep disturbance and sleep deprivation, fatigue, headache, loss of attention and alertness, reduced motivation, and exposure to a higher risk of cardiovascular disease[35,36].

Shift work (SW) with night work, due to the frequent changes of daily light profiles, disrupts the normal circadian sleep-wake cycle and is associated with impaired health. In particular, sleep disturbances and sleep deprivation represent the most common problems among rotational shift workers and night workers[37,38]. Moreover, the altered phase misalignment between the internal clockwork and the external environment causes decreased metabolic efficiency and disrupted cardiac function[39]. Energy intake and expenditure, sleep deprivation and fat intake have crucial roles in the genesis of obesity, metabolic syndrome and diabetes[40]. Thus, night shift workers sleep fewer hours, have a higher weight and body mass index and have an almost three times higher rate of abdominal obesity than day shift workers[41].

In addition to metabolic disturbances, SW is associated with an increased overall risk of mental health disorders, in particular, depression. A meta-analysis[42] of more than 28,000 subjects showed that SW women were more likely to experience depressive symptoms than non-SW women. Nursing, characterized by working in shifts to ensure continuity of care throughout the 24 hours, is a prototype of SW. Thus, circadian rhythm desynchronization may be associated with adverse effects on nurses' health, since SW is associated with an alteration in psychophysical homeostasis, an obstacle for social and family relationships, and it represents a risk factor for stress, sleep disorders, metabolic disorders, diabetes, and cardiovascular disorders[43].

The results of a systematic review showed that working night shifts increased the odds of sickness absence in nurses, a common indicator of a stressful occupation[44]. Shift workers are more likely to have unhealthy habits and sleep deprivation, and eating behavior is associated with a more unbalanced diet and abnormal eating patterns among female nurses[45]. Shan and colleagues showed that the duration of rotating night shift work and unhealthy lifestyle were independently and jointly associated with a higher risk of type 2 diabetes mellitus among nurses[46]. A randomized, double-blind, crossover controlled clinical trial conducted on a sample of overweight female nurses working on a fixed night shift showed that a short duration of nighttime sleep and high social jet lag (SJL)–the asynchrony between one's chronotype and social working hours–were risk factors for dyslipidemia[47]. In particular, 1 h less of nighttime sleep increased very-low-density lipoprotein cholesterol levels by 2.8 mg/dL[47].

Circadian misalignment and its adverse effects on metabolism seem to show sex-specific differences independent of behavioral and/or environmental factors. In fact, the 24 h average levels of

the satiety hormone leptin exhibit a 7% decrease in women and an 11% increase in men, whereas only in women does the hunger hormone ghrelin increase by 8% during wake periods[48]. Chronotype plays a crucial role as well. A South Korean study[49] on shift-working nurses revealed that SJL, day-shift fatigue, and sleep quality during night shifts affected the nurses' sleep quality, and these variables accounted for nearly 25% of the variance in overall sleep quality. Again, a study[50] on nurses working in a three-shift schedule (3S), firefighters working in a 24-h-every-other-day shift schedule (EOD), and dayworkers (DW) showed that sleep disturbances were more frequent in shift workers than DWs, and the evening chronotype had a relationship to the depressive mood in shift workers. A systematic review[51] showed that evening-oriented female nurses were more likely to show sleep disorders, insomnia, fatigue, and anxiety than men and morning-oriented women. Finally, sleep deprivation may also be a source of long-term risk. In fact, positivity during screening for a sleep disorder in hospital shift workers was associated with an 83% increased incidence of adverse safety outcomes in the following six months, such as motor vehicle crashes, near-miss crashes and occupational exposures[52].

Parasomnias and nightmares represent common complications of SW in nurses as well. A Norwegian study[53] conducted on more than 2,000 nurses (91% women) with different work schedules showed that nurses working a 2-shift (day and evening) rotational schedule and a 3-shift (day, evening and night) rotational schedule had a higher prevalence of parasomnias than nurses working days or nights only. Statistical significance was found for confusional arousal and nightmares (OR 2.10 *vs.* 1.71 and 1.64 *vs.* 1.57, respectively), and crude logistic regression with nightmares as the dependent variable showed that age, being married/cohabiting, and caffeine intake were negatively associated with nightmares, whereas working 2-shift or 3-shift rotations were associated with an increased risk of nightmares[53]. In the adjusted analysis, 2-shift and 3-shift rotational schedules remained significant, increasing the risk of nightmares by 57% and 36%, respectively[53]. A Turkish study[54] on more than 1,400 participants, with three different professional groups working different shift schedules (daytime, night, or rotating shifts), showed that the lifetime and 1-year parasomnia (including nightmares) prevalence were 44% and 24.4 overall, respectively. In particular, the 1-year parasomnia prevalence

among and daytime workers was 28% and 13%, respectively, and working rotating shifts were an independent risk factor for parasomnias[54]. Nightmares and nightmare severity also showed sex/gender and chronotype-linked associations. In fact, nightmares were recalled more frequently and rated as more distressing by E-type women than by M-type women[55]. This association did not hold for men, and the eveningness/nightmares association in women showed age-dependent variations[55]. A tentative explanation could be that E-types, compared with M-types, habitually wake up at a later clock time and during an earlier circadian phase, closer to the nadir of the core body temperature (CBT) rhythm[27,28,56]. Since the acrophase of REM sleep propensity coincides with the CBT minimum, E-types could be more likely to recall the most intense dreams (and nightmares)[57,58].

Time of Day and Performance

A few years ago, an interesting study[59] investigated the circadian and sleep-wake-dependent regulation of cognition in a sample of men and women in a forced dyssynchrony protocol. The authors found circadian effects for reported sleepiness, mood, and effort in both men and women, but with quantitative differences by sex. In fact, the amplitude of circadian modulation was greater in women by several performance measures, so their performance was impaired in the early morning hours. In particular, the largest circadian modulation was observed for effort, whereas accuracy exhibited the largest sex difference in circadian modulation[59]. Thus, the relationship between circadian rhythmicity, sex, and impaired morning performance may have implications for SW, since nurses are usually women.

The hypothesis of an association between nightshift work and decreased psychomotor vigilance has been further confirmed by Behrens et al[60], who studied the mean reaction time, percentage of lapses and false starts, combining reaction time and error frequencies, in a sample of female shift workers. At the end of a night shift, reaction times were increased, and the number of lapses was higher compared to day shifts[60]. Time-of-day and optimal performance are strictly connected, and brain imaging studies performed with functional magnetic resonance found that task performance during nonoptimal times of the day may result in cognitive impairments leading to increased error rates and slower reaction times[61]. The so-called 'synchrony effect' (in other words,

better performance at optimal times of the day according to the chronotype) plays a role in cognitive performance. A group of young, healthy participants, divided into M-types and E-types, performed a given task in two sessions, in the morning and in the evening[62]. E-types were more accurate in the task than M-types, regardless of the time of day. Based on both objective measures (reaction times for hits, false alarms) and subjective evaluations (effort put into the performance), the reaction times were slower in the morning, whereas the effort was greater in the evening[62].

A study[63] on more than 500 female nurses working fixed day and rotating night shifts in the United Arab Emirates reported that rotating night shift nurses were more likely to have evening or intermediate chronotypes and more likely to report an alignment of shift work to their chronotype compared with fixed day shift participants. Very recently, a systematic review[64] examined the association between chronotype, heart rate variability (HRV), mood and stress response. Despite the diversity of study designs, the results showed that chronotype was associated with HRV, and individual chronotype does not play a secondary role in determining the level of performance. In fact, it has been showed[64] that E-types performed better during the evening or nighttime tasks, whereas M-types performed better during morning activities. Specifically, E-types showed decreased HRV and HRV recovery in relation to tasks performed during the morning or daytime compared to M-types[64].

For health care professionals, errors represent the downside of performance, and medication errors in particular are a major concern for health care systems worldwide. The 'near misses', defined by the World Health Organization as "an error that has the potential to cause an adverse event (patient harm) but fails to do so because it is intercepted"[65], are the most frequently reported incidents. This is particularly important for nurses since medication administration accounts for 40% of the nursing clinical activity in hospitals, and nurses, being directly responsible for the patient's care and safety, play a crucial role[66]. Although the results from a systematic review indicated stress, fatigue, increased workload, night shifts, nurse staffing ratio, and workflow interruptions as the main reasons for medication errors[66], circadian misalignment and related consequences, such as sleep deprivation, daytime sleepiness, difficulty maintaining wakefulness and alertness during waking hours, repre-

sent factors impairing performance and causing errors. Nurses' sleep quality immediately prior to a working 12-h shift, was shown to be more predictive of error than sleep quantity[67], but lack of adequate resting can have consequences on nursing performance even in the presence of self-perceived high quality of sleep. A recent web survey-based study[68] evaluated the quality of sleep and self-perception risk of medication errors in a large sample of Italian nurses. Poor quality of sleep was found in 88% of subjects, and the risk of medication errors during the last shift was reported by 76% of them, although more than 60% of nurses reported a self-perceived good/excellent quality of sleep. Thus, the risk of medication errors was associated with a poor quality of sleep and was independently associated with a short resting time after a night shift and a poor self-perception quality of sleep (OR 3.165, p=0.003)[68]. Another study[69], deliberately based on the same methodological design, showed that the perception of the risk of medication errors was also present in one out of two midwives in Italy. In particular, midwives who were younger, who had less working experience, and who operated in shiftwork, were at higher risk of potential medication error.

Conclusions

The quality of sleep is the most influential parameter of workers' quality of life, not only in night shift workers but also for white-collar daytime workers[70]. Although the wide heterogeneity of the studies may represent a potential source of bias, a growing body of evidence indicates the existence of a close association between circadian rhythms, sleep, general and psychological health, and working performance. Moreover, personal circadian preference (chronotype) seems to play a crucial role. In fact, a study of older nurses working in direct patient care in the United States identified factors at the (1) individual, (2) unit-based work level and (3) organizational level associated with work ability[71]. 'Protective' individual factors include teamwork and feeling healthy and capable of doing their job. For unit-based work, a schedule capable of accommodating work-life balance and personal chronotype promotes work ability[71]. Nightmares, coupled in a bidirectional manner with stress, shiftwork, and chronotype, represent a complicated puzzle of good health and perfor-

mance in nurses. Assessment of individual chronotype and sleep attitude by means of validated questionnaires has been proposed as an easy and inexpensive way to identify nurses at a higher risk of developing metabolic diseases[72]. In fact, the results from a national, cross-sectional study of nurses in the United States showed that nurses with mismatched chronotype and above average sleep quality had an estimated 3.5 times higher odds of being obese[73]. The assessment of chronotype could represent a tool to identify health care personnel at higher risk of circadian disruption, to mitigate work-related stress, to produce better sleep quality, to improve personal performance, and finally to reduce the potential risk of possible errors. Thus, the organizational policy could consider ergonomic turnaround, characterized by proper shift assignment, chronotype and alignment with shift work, as well as a novel model for work schedules that allows for adequate off-duty days for sleep recovery among nurses and that limits absenteeism due to sickness.

Authors' Contribution

Conceptualization, R.C, A.D.G., F.F. and R.M.; Methodology, B.B., R.T.; Literary analysis, A.D.G., B.B., R.T.; Resources, R.C., R.M.; Writing – original draft preparation, R.C, A.D.G., B.B., R.T.; Writing – review and editing, P.J. L-S, F.F. and R.M.; Supervision, P.J. L-S, F.F. and R.M.; Project administration, F.F.; Funding acquisition, R.M. All authors have read and agreed to the published version of the manuscript.

References

1) Kahn RL, Wolfe DM, Quinn RP, Snoek JD. Organizational stress: studies in role conflict and ambiguity. New York: John Wiley & Sons, Inc.; 1964.

2) Menzies IEP. Nurses under stress. Internatl Nurs Rev 1960; 7: 9-16.

3) Freudenberger HJ. Staff burn-out. J Social Issues 1974; 30: 159-185.

4) Jennings BM. Work stress and burnout among nurses: role of the work environment and working conditions. In Hughes RG (ed.): Patient Safety and Quality: An Evidence-Based Handbook for Nurses. Rockville (MD): Agency for Healthcare Research and Quality (US); Chapter 26, p. 2-127-2-158, 2008.

5) Albendín-García L, Suleiman-Martos N, Cañadas-De la Fuente GA, Ramírez-Baena L, Gómez-Urquiza JL, De la Fuente-Solana EI. Prevalence, related factors, and levels of burnout among midwives: a systematic review. J Midwifery Womens Health 2021; 66: 24-44.

6) Manfredini R, Boari B, Tiseo R, Salmi R, Manfredini F. Circadian rhythm effects on cardiovascular and other stress-related events. In: Fink G, ed. Stress: Neuroendocrinology and Neurobiology. Academic Press, Cambridge, MA, USA; 2017: 401-409.

7) Paul F, Alpers GW, Reinhard I, Schredl M. Nightmares do result in psychophysiological arousal: A multimeasure ambulatory assessment study. Psychophysiology 2019; 56: e13366.

8) Nagy T, Salavecz G, Simor P, Purebl G, Bódizs R, Dockray S, Steptoe A. Frequent nightmares are associated with blunted cortisol awakening response in women. Physiol Behav 2015; 147: 233-237.

9) Nguyen TT, Madrid S, Marquez H, Hicks, RA. Nightmare frequency, nightmare distress and anxiety. Percept Mot Skills 2002; 95: 219-225.

10) Kroth J, Thompson L, Jackson J, Pascali L, Ferreira M. Dream characteristics of stockbrokers after a major market downturn. Psychol Rep 2002; 90: 1097-1100.

11) Nowakowski S, Meers J, Heimbach E. Sleep and women's health. Sleep Med Res 2013; 4: 1-22.

12) Cappadona R, De Giorgi A, Di Simone E, Zucchi B, Rodriguez-Borrego MA, Lopez-Soto PJ, Fabbian F, Manfredini R. Sleep, dreams, and sex-related differences: a narrative review. Eur Rev Med Pharmacol Sci 2021; 25: 3054-3065.

13) Kling JM, Kapoor E, Mara K, Faubion SS. Associations of sleep and female sexual function: good sleep quality matters. Menopause 2021; 28: 619-625.

14) Singh S, Kaur H, Singh S, Khawaja I. Parasomnias: a comprehensive review. Cureus 2018; 10: e3807.

15) American Psychiatric Association (APA). Diagnostic and statistical manual of mental disorders. DSM-5. Arlington, VA: American Psychiatric Publishing, 2013.

16) American Academy of Sleep Medicine (AASM). International classification of sleep disorders – third edition. ICSD-3. Darien, IL: AASM, 2014.

17) Gieselmann A, Ait Aoudia M, Carr M, Germain A, Gorzka R, Holzinger B, Kleim B, Krakow B, Kunze AE, Lancee J, Nadorff MR, Nielsen T, Riemann D, Sandahl H, Schlarb AA, Schmid C, Schredl M, Spoormaker VI, Steil R, van Schagen AM, Wittmann L, Zschoche M, Pietrowsky R. Aetiology and treatment of nightmare disorder: State of the art and future perspectives. J Sleep Res 2019; 28: e12820.

18) Kinoshita Y, Itani O, Otsuka Y, Matsumoto Y, Nakagome S, Kaneita Y. A nationwide cohort study of parasomnias among adolescents. J Clin Psychiatry 2021; 82: 20m13648.

19) Schredl M, Reinhard I. Gender differences in nightmare frequency: A meta-analysis. Sleep Med Rev 2011; 15: 115-121.

20) Garcia O, Slavish D, Dietch JR, Messman BA, Contractor AA, Haynes PL, Pruiksma KE, Kelly K, Ruggero C, Taylor DJ. What goes around comes around: Nightmares and daily stress are bidirectionally associated in nurses. Stress Health 2021 Mar 21. doi: 10.1002/smi.3048. Online ahead of print.

21) Lin YQ, Lin ZX, Wu YX, Wang L, Zeng ZN, Chen QY, Wang L, Xie XL, Wei SC. Reduced sleep duration and sleep efficiency were independently associated with frequent nightmares in Chinese frontline medical workers during the Coronavirus disease 2019 outbreak. Front Neurosci 2021; 14: 631025.

22) Dietch JR, Taylor DT, Pruiksma K, Wardle-Pinkston S, Slavish DC, Messman B, Estevez R, Ruggero CJ, Kelly K. The Nightmare Disorder Index: development and initial validation in a sample of nurses. Sleep 2021; 44: zsaa254.

23) Dunlap JC. Molecular bases for circadian clocks. Cell 1999; 96: 271-290.

24) Thosar SS, Shea SA. Circadian control of human cardiovascular function. Curr Opin Pharmacol 2021; 57: 89-97.

25) Cappadona R, Di Simone E, De Giorgi A, Zucchi B, Fabbian F, Manfredini R. Biological rhythms, health, and gender-specific differences. It J Gender-Specific Med 2021; 7: 109-115.

26) Horne JA, Ostberg O. A self-assessment questionnaire to determine morningness-eveningness in human circadian rhythms. Int J Chronobiol 1976; 4: 97-110.

27) Baehr EK, Revelle W, Eastman CI. Individual differences in the phase and amplitude of the human circadian temperature rhythm: with an emphasis on morningness-eveningness. J Sleep Res 2000; 9: 117-127.

28) Duffy JF, Dijk DJ, Hall EF, Czeisler CA. Relationship of endogenous circadian melatonin and temperature rhythms to self-reported preference for morning or evening activity in young and older people. J Investig Med 1999; 47: 141-150.

29) Randler C, Engelke J. Gender differences in chronotype diminish with age: a meta-analysis based on morningness/chronotype questionnaires. Chronobiol Int 2019; 36: 888-905.

30) Fabbian F, Zucchi B, De Giorgi A, Tiseo R, Boari B, Salmi R, Cappadona R, Gianesini G, Bassi E, Signani F, Raparelli V, Basili S, Manfredini R. Chronotype, gender and general health. Chronobiol Int 2016; 33: 863-882.

31) Gibertini M, Graham C, Cook MR. Self-report of circadian type reflects the phase of the melatonin rhythm. Biol Psychol 1999; 50: 19-33.

32) Gowen R, Filipowicz A, Ingram KK. Chronotype mediates gender differences in risk propensity and risk-taking. PLoS One 2019; 14: e0216619.

33) Manfredini R, Manfredini F, Fersini C, Conconi F. Circadian rhythms, athletic performance, and jet lag. Br J Sports Med 1998; 32: 101-106.

34) Manfredini R, Fabbian F, De Giorgi A, Zucchi B, Cappadona R, Signani F, Katsiki N, Mikhailidis DP. Daylight saving time and myocardial infarction: should we be worried? A review of the evidence. Eur Rev Med Pharmacol Sci 2018; 22: 750-755.

35) Manfredini R, Fabbian F, Cappadona R, Modesti PA. Daylight saving time, circadian rhythms, and cardiovascular health. Intern Emerg Med 2018; 13: 641-646.

36) Manfredini R, Fabbian F, Cappadona R, De Giorgi A, Bravi F, Carradori T, Flacco ME, Manzoli L. Daylight saving time and acute myocardial infarction: a meta-analysis. J Clin Med 2019; 8: 404.

37) Akerstedt T. Shift work and disturbed sleep/wakefulness. Occ Med 2003; 53: 89-94.

38) Sack RL, Auckley D, Auger RR. Circadian rhythm sleep disorders: Part I, basic principles, shift work and jet lag disorders. An American Academy of sleep medicine review. Sleep 2007; 30: 1460-1483.

39) West AC, Smith L, Ray DW, Loudon ASI, Brown TM, Bechtold DA. Misalignment with the external light environment drives metabolic and cardiac dysfunction. Nat Commun 2017; 8: 417.

40) Garaulet M, Ordovás JM, Madrid JA. The chronobiology, etiology and pathophysiology of obesity. Int J Obes (Lond) 2010; 34: 1667-1683.

41) Brum MCB, Dantas Filho FF, Schnorr CC, Bertoletti OA, Bottega GB, da Costa Rodrigues T. Night shift work, short sleep and obesity. Diabetol Metab Syndr 2020; 12: 13.

42) Torquati L, Mielke GI, Brown WJ, Burton NW, Kolbe-Alexander TL. Shift work and poor mental health: A meta-analysis of longitudinal studies. Am J Public Health 2019; 109: e13-20.

43) Rosa D, Terzoni S, Dellafiore F, Destrebecq A. Systematic review of shift work and nurses' health. Occup Med (Lond) 2019; 69: 237-243.

44) Gohar B, Larivière M, Lightfoot N, Wenghofer E, Larivière C, Nowrouzi-Kia B. Meta-analysis of nursing-related organizational and psychosocial predictors of sickness absence. Occup Med (Lond) 2020; 70: 593-601.

45) Yoshizaki T, Kawano Y, Noguchi O, Onishi J, Teramoto R, Sunami A, Yokohama Y, Tada Y, Hida A, Togo F. Association of eating behaviours with diurnal preference and rotating shift work in Japanese female nurses: a cross-sectional study. BMJ Open 2016; 6: e011987.

46) Shan Z, Li Y, Zong G, Guo Y, Li J, Manson JE, Hu FB, Willett WC, Schernhammer ES, Bhupathiraju SN. Rotating night shift work and adherence to unhealthy lifestyle in predicting risk of type 2 diabetes: results from two large US cohorts of female nurses. BMJ 2018; 363: k4641.

47) Felix Garrido AL, de Sousa Duarte A, Teixeira Santana P, Rodrigues GH, Pellegrino P, Fidalgo Ramos Nogueira L, Cipolla-Neto J, de Castro Moreno CR, Marqueze EQ. Eating habits, sleep, and a proxy for circadian disruption are correlated with dyslipidemia in overweight night workers. Nutrition 2021; 83: 111084.

48) Qian J, Morris CJ, Caputo R, Wang W, Garaulet M, Scheer FAJL. Sex differences in the circadian misalignment effects on energy regulation. Proc Natl Acad Sci USA 2019; 116: 23806-23812.

49) Kang H, Lee M, Jang SJ. The impact of social jetlag on sleep quality among nurses: a cross-sectional survey. Int J Environ Res Public Health 2020; 18: 47.

50) Choi SJ, Song P, Suh S, Joo EY, Lee SI. Insomnia symptoms and mood disturbances in shift workers with different chronotypes and working schedules. J Clin Neurol 2020; 16: 108-115.

51) López-Soto PJ, Fabbian F, Cappadona R, Zucchi B, Manfredini F, Garcia-Arcos A, Carmona-Torres JM, Manfredini R, Rodriguez-Borrego MA. Chronotype, nursing activity, and gender: a systematic review. J Adv Nurs 2019; 75: 734-748.

52) Weaver MD, Vetter C, Rajaratnam SMW, O'Brien CS, Qadri S, Benca RM, Rogers AE, Leary EB, Walsh JK, Czeisler CA, Barger LK. Sleep disorders, depression and anxiety are associated with adverse safety outcomes in healthcare workers: A prospective cohort study. J Sleep Res 2018; 27: e12722.

53) Bjorvatn B, Magerøy N, Moen BE, Pallesen S, Waage S. Parasomnias are more frequent in shift workers than in day workers. Chronobiol Int 2015; 32: 1352-1358.

54) Kurt Gök D, Ünal İ, Aslan-Kara K. Evaluation of the effects of shift work on parasomnia prevalence. Chronobiol Int 2021; 38: 1500-1506.

55) Nielsen T. Nightmares associated with the eveningness chronotype, J Biol Rhythms 2010; 25: 53-62.

56) Mongrain V, Lavoie S, Selmaoui B, Paquet J, Dumont M. Phase relationships between sleep-wake cycle and underlying circadian rhythms in morningness-eveningness. J Biol Rhythms 2004; 19: 248-257.

57) Giannotti F, Cortesi F, Sebastiani T, Ottaviano S. Circadian preference, sleep and daytime behaviour in adolescence. J Sleep Res 2002; 11: 191-199.

58) Korczak AL, Martynhak BJ, Pedrazzoli M, Brito AF, Louzada FM. Influence of chronotype and social zeitgebers on sleep/wake patterns. Braz J Med Biol Res 2008; 41: 914-919.

59) Santhi S, Lazar AS, McCabe PJ, Lo JC, Groeger JA, Dijk DJ. Sex differences in the circadian regulation of sleep and waking cognition in humans. Proc Natl Acad Sci USA 2016; 113: E2730-2739.

60) Behrens T, Burek K, Pallapies D, Kösters L, Lehnert M, Beine A, Wichert K, Kantermann T, Vetter C, Brüning T, Rabstein S. Decreased psychomotor vigilance of female shift workers after working night shifts. PLoS One 2019; 14: e0219087.

61) Reske M, Rosenberg J, Plapp S, Kellermann T, Shah NJ. fMRI identifies chronotype-specific brain activation associated with attention to motion–why we need to know when subjects go to bed. Euroimage 2015; 111: 602-610.

62) Ceglarek A, Hubalewska-Mazgaj M, Lewandowska K, Sikora-Wachowicz B, Marek T, Fafrowicz M. Time-of-day effects on objective and subjective short-term memory task performance. Chronobiol Int 2021; 38: 1330-1343.

63) Issa WB, Rahman HA, Albluwi N, Samsudin ABR, Abraham S, Saqan R, Naing L. Morning and evening salivary melatonin, sleepiness and chronotype: A comparative study of nurses on fixed day and rotating night shifts. J Adv Nurs 2020; 76: 3372-3384.

64) Honkalampi K, Järvelin-Pasanen S, Tarvainen MP, Saaranen T, Vauhkonen A, Kupari S, Perkiö-Mäkelä M, Räsänen K, Oksanen T. Heart rate variability and chronotype - a systematic review. Chronobiol Int 2021 Jun 16:1-11. doi: 10.1080/07420528.2021.1939363. Online ahead of print.

65) World Health Organization. World Alliance for Patient Safety: WHO Draft Guidelines for Adverse Event Reporting and Learning Systems: From Information to Action; World Health Organization: Geneva, Switzerland, 2005.

66) Di Muzio M, Dionisi S, Di Simone E, Cianfrocca C, Di Muzio F, Fabbian F, Barbiero G, Tartaglini D, Giannetta N. Can nurses' shift work jeopardize the patient safety? A systematic review. Eur Rev Med Pharmacol Sci 2019; 23: 4507-4519.

67) Weaver AL, Stutzman SE, Supnet C, Olson DM. Sleep quality, but not quantity, is associated with self-perceived minor error rates among emergency department nurses. Int Emerg Nurs 2016; 25: 48-52.

68) Di Simone E, Fabbian F, Giannetta N, Dionisi S, Renzi E, Cappadona R, Di Muzio M, Manfredini R. Risk of medication errors and nurses' quality of sleep: a national cross-sectional web survey study. Eur Rev Med Pharmacol Sci 2020; 24: 7058-7062.

69) Cappadona R, Di Simone E, De Giorgi A, Boari B, Di Muzio M, Greco P, Manfredini R, Rodrí-guez-Borrego MA, Fabbian F, López-Soto PJ. Individual circadian preference, shift work, and risk of medication errors: a cross-sectional web survey among Italian midwives. Int J Environ Res Public Health 2020; 17: 5810.

70) Stendardo M, Maietti E, Masotti E, Bianchi E, Manfredini R, Boschetto P. Sleep quality: a critical determinant of perceived quality of life in the administrative-technical workers of an Italian university. Eur Rev Med Pharmacol Sci 2020; 24: 13025-13036.

71) Witkoski Stimpfel A, Arabadjian M, Liang E, Sheikhzadeh A, Schecter Weiner S, Vaughan Dickson V. Organization of work factors associated with work ability among aging nurses. West J Nurs Res 2020; 42: 397-404.

72) Manfredini R, Cappadona R, Fabbian F. Nurses, shift work, and diabetes: should later chronotype be considered as a risk factor? BMJ 2019; 364: l178.

73) Hittle BM, Caruso CC, Jones HJ, Bhattacharya A, Lambert J, Gillespie GL. Nurse health: the influence of chronotype and shift timing. West J Nurs Res 2020; 42: 1031-1041.