

LONG TERM EFFECTS OF NON-STOP OPERATIONS. EMERGENCY SITUATIONS PERSONNEL SPECIFICITIES

Lucian-Ionel CIOCA^{*,**}, Lucian TREFAȘ^{*}, Alexandra-Simona TREFAȘ^{***}

^{*}“Lucian Blaga” University of Sibiu, Romania

^{**}Academy of Romanian Scientists, Bucharest, Romania

^{***}“Nicolae Bălcescu” Land Forces Academy, Sibiu, Romania

lucian.trefas@ulbsibiu.ro, trefas.alexandra@armyacademy.ro, lucian.cioca@ulbsibiu.ro

Abstract: Shift work is widely spread as a way to organize the schedule for workplaces in many domains. While having many advantages in the use of a work place more efficiently and the precise timing of delivering results, there are also many disruptions that occur especially in the field of safety and security of workers. Shift work constitutes a multifactorial health hazard affecting circadian physiology, acute performance, and long-term disease risk (gastro-intestinal, metabolic, cardiovascular, oncologic, reproductive and mental health). Effective mitigation requires a systemic approach that integrates ergonomic shift design, regular medical surveillance, worker education and organizational support. This article aims at presenting an analysis of the long-term effects on a branch of work that has unique specificities, fire-fighters. Nevertheless, the paper provides a wide range of recommendations in order to mitigate these effects and presents scientific reasons for implementing an array of procedures that lead to a better organised workplace and prolonged professional activity.

Keywords: shift work, safety, workplace, occupational risks, circadian cycle

1. Introduction

Work place safety and security is a very broad domain that brings along a large amount of both scientific research, as well as practical implementation measures. Nevertheless, the health risks associated with modern shift-work schedules can be mitigated with organizational and medical measures to protect workers.

Apply sustainable solutions, such as waste-reduction protocols and energy-efficient lighting, to reduce hazards. Continuously monitor performance metrics and update policies to adapt to emerging risks, fostering a culture of proactive safety [7].

Furthermore, there are three main domains of research in order to study and reduce the effects of shift work: sleep and circadian disruptions, chronic diseases and preventive measures.

Shift work, especially night work, forces a misalignment between the endogenous circadian clock and the external light-dark cycle [5].

There is a large array of diseases that have scientific arguments to be linked with shift work: psychological and mental health, gastro-intestinal problems, metabolic syndrome, cardiovascular, cancer, and reproductive health.

Organizational interventions – Additional rest breaks, nap opportunities, flexible working-time arrangements, improved canteen facilities, transport services and periodic transfers to day work are recommended to mitigate fatigue and health risks [5].

Therefore, it is clear that around the clock workplaces have damaging effects on both efficiency and longevity and scientific

research provide a number of interventions to mitigate these effects. The question we aim at providing an answer for is how these recommendations could be implemented in the work environment of fire-fighters.

2. Scientific considerations

2.1. Circadian disruptions

When the alignment between the endogenous clock and the external schedule fails, circadian rhythm sleep disorders emerge. Two of the most common forms are delayed sleep-phase syndrome and advanced sleep-phase syndrome. Patients with delayed sleep-phase syndrome cannot fall asleep until the early morning hours and struggle to awaken until late morning or early afternoon, despite normal sleep architecture once they finally do sleep [1].

Therapeutic approaches aim to re-entrain the circadian clock to a socially acceptable schedule. Bright-light exposure is the cornerstone of treatment. For delayed sleep-phase syndrome, timed exposure to bright light in the early morning combined with gradual evening phase advances can shift the rhythm earlier [21].

2.2. Chronic long term effects

Sleep disorders have far-reaching, long-term consequences that affect physical health, mental well-being, and societal costs.

Sleep disorders significantly increase cardiovascular risk, contributing to approximately 38,000 deaths each year in the United States. Although the article emphasizes cardiovascular consequences, it provides limited discussion of metabolic outcomes such as obesity or diabetes, suggesting a need for further research on these associated risks and underscores the need for early clinical intervention [20].

Sleep disorders are tightly linked to psychological and mental health conditions. They coexist with psychoses, mood disorders, anxiety, panic disorders, alcoholism, and worsening symptom severity [23]. Chronic insomnia can precede depressive episodes, suggesting a causal role. Psychiatric illnesses often present with

sleep-onset difficulty, frequent arousals, fragmented sleep, reduced total sleep time, and lower sleep efficiency. Stressful life events, rumination, and emotional inhibition can trigger chronic insomnia, further aggravating anxiety and depression. Addressing both sleep and mental health through combined pharmacologic and behavioral therapies are essential to break this bidirectional cycle for improved overall wellbeing and quality [13].

Sleep disturbances are closely tied to gastrointestinal dysfunction. It is noted that sleep disorders may coexist with gastroesophageal reflux [8], peptic ulcer disease, irritable bowel syndrome, and fibromyalgia, reflecting bidirectional pathophysiology [16]. Fragmented or insufficient sleep can exacerbate acid secretion, impair esophageal clearance, and heighten visceral sensitivity, worsening reflux symptoms. Conversely, nocturnal reflux and abdominal discomfort disrupt sleep continuity, fostering insomnia and daytime fatigue. Chronic sleep loss also alters gut motility and micro biota, contributing to dyspepsia and bowel irregularities. Recognizing and treating the underlying sleep disorder can therefore alleviate gastrointestinal complaints and improve overall health for patients in clinical practice [4].

Sleep disorders are strongly associated with metabolic syndrome, a cluster of abdominal obesity, insulin resistance, dyslipidemia and hypertension that elevates cardiovascular risk. Addressing sleep hygiene, treating apnea with CPAP, and implementing behavioral interventions can mitigate these metabolic disturbances, reducing long-term morbidity and improve health outcomes [18].

Large population-based studies have identified insomnia, obstructive sleep apnea, hypersomnia, and circadian-rhythm disorders as risk factors for a wide spectrum of cancers. Insomnia was associated with a 24 % higher incidence of tumors, especially when the disorder persisted for more than ten years [15]. Obstructive sleep apnea correlated with increased incidence of

melanoma, breast, uterine, kidney, pancreatic, colorectal, and central-nervous-system cancers, with a particularly strong signal for breast cancer in women [19]. Hypersomnia, including narcolepsy, showed elevated risks for head-neck, gastric, colorectal, liver, breast and lung cancers [11]. Circadian-rhythm disorders were linked to gastrointestinal, breast, squamous-cell, thyroid and prostate cancers, although some evidence remains tentative [19].

Because sleep disorders often precede cancer diagnosis and can persist after oncologic treatment, systematic screening for insomnia, obstructive sleep apnea, hypersomnia, and circadian-rhythm disturbances should become routine in oncology care. Early identification enables interventions – such as continuous positive airway pressure for obstructive sleep apnea, cognitive-behavioral therapy for insomnia, or chrono therapy timing of chemotherapeutic agents –that may not only improve quality of life, but also mitigate tumor progression [6].

Sleep exerts a profound influence on reproductive health through hormonal regulation, circadian signaling, and metabolic balance that directly affect gonadal hormone secretion and reproductive behavior [26]. Disrupted sleep alters the nocturnal surge of melatonin and the diurnal patterns of cortisol, growth hormone, prolactin, glucose and insulin, which together shape ovarian function, menstrual regularity and fertility. For women, prolonged sleep (>9 h) has been linked to a higher incidence of estrogen-receptor-positive breast cancer, suggesting that excessive sleep may perturb estrogen metabolism and increase breast tissue susceptibility. Conversely, short sleep (≤ 6 h) compromises ovulation and sperm quality. Overall, adequate, well-timed sleep supports the neuro-endocrine circuitry that governs reproductive cycles, while chronic sleep disturbances can dysregulate hormone axes, increase inflammatory mediators and ultimately diminish reproductive health [2].

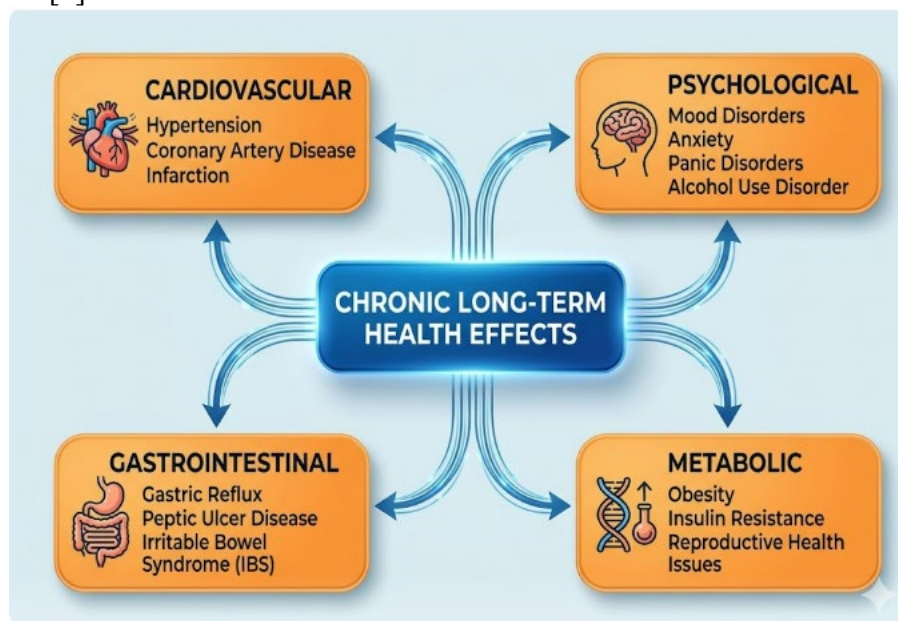


Figure 1: Chronic long term effects of circadian disruptions

2.3. Preventive measures

Sleep disorders affect millions of individuals across the lifespan, ranging from insomnia and obstructive sleep apnea to circadian-rhythm disturbances and parasomnias. Below is a synthesis of evidence-based measures that can be incorporated at the individual, family, and health-system levels.

Regularity is a cornerstone of circadian health. Going to bed and waking at the same time each day, even on weekends, helps synchronize the internal clock, stabilizes melatonin secretion, and reduces sleep latency. For children and adolescents, a predictable bedtime routine that includes calming activities (e.g., reading, warm baths) can reinforce this schedule. Adults benefit from limiting exposure to bright light in the evening and using dim lighting to signal the approach of sleep.

A quiet, dark, and comfortably cool bedroom supports the physiological processes that facilitate sleep onset and maintenance. Key environmental adjustments include: light control, noise reduction, and temperature.

For infants, safe-sleep guidelines are especially critical. The study of pediatric emergency-department clinicians highlighted core recommendations such as placing infants on their backs, using a firm sleep surface, and avoiding soft bedding, pillows or bumper pads, all of which reduce the risk of sudden unexpected infant death and related sleep-related disorders [11]. These practices also model a safe environment that can be extended to older children.

Physical activity, nutrition, and substance use directly influence sleep quality. Therefore, regular moderate-intensity activity, preferably earlier in the day, improves sleep efficiency and reduces insomnia symptoms. Furthermore, limiting caffeine and heavy meals within four hours of bedtime; alcohol, while initially sedating, and fragments rapid eye movement sleep should be avoided. Nonetheless, nicotine is

a stimulant that disrupts sleep architecture; quitting improves both sleep latency and continuity [17].

Knowledge empowers individuals to adopt preventive behaviors. Educational initiatives should emphasize consistent routines, environment optimization and lifestyle choices. Age-specific guidance for infants: back-sleeping, firm surface, room-sharing without bed-sharing are essential; for school-age children: limiting screen time and encouraging regular physical activity are very important.

Effective prevention of sleep disorders requires a multi-tiered approach that aligns individual habits with supportive environments and health-system infrastructure. Clinicians should assess sleep habits routinely, provide tailored counselling, and utilize system tools, such as EMR prompts and multilingual resources, to reinforce messages. Families benefit from clear, culturally sensitive education that translates guidelines into daily practice. When these layers operate synergistically, the burden of sleep disorders can be markedly reduced, fostering healthier communities across the lifespan [12].

3. Firefighter's specificity

Firefighters are exposed to a unique combination of inhalable irritants, heat, and physical stress that predisposes them to several respiratory diseases that differ in prevalence and severity from the general population. The most consistently reported condition in the literature on Dutch firefighters is bronchial hyperresponsiveness, heightened airway reactivity to bronchoconstriction agents such as meth choline [3]. It is therefore clear that repeated exposure to fire smoke can induce chronic airway sensitization, especially in those already predisposed by allergic sensitization. Another disease that emerges from the same cohort is asthma, which was assessed both by self-report and by objective meth choline challenge. The questionnaire data revealed that 8.5% of firefighters reported ever

having asthma, a prevalence that was significantly higher than that observed in a comparable Dutch general population. Although the study did not find a direct dose-response link between fire-related exposure metrics and asthma prevalence, the coexistence of asthma and bronchial hyper responsiveness in the same individuals underscores a shared pathophysiological pathway driven by irritant inhalation and atopic status. It is noted that the relatively low overall prevalence of respiratory symptoms, despite the elevated asthma rate, may reflect a “healthy worker effect” combined with mandatory medical surveillance [10].

In contrast, one could not identify significant associations between fire-related exposure and baseline lung-function parameters.

Overall, a disease spectrum is clearly delineated in firefighters; the spectrum is dominated by irritant-induced airway hyper reactivity, asthma, and atrophy-related susceptibility, while classic obstructive lung-function decline appears less prevalent. The authors conclude that heightened awareness and stricter adherence to individual breathing protection use, even during low-visibility fires, are essential preventive measures to curb the development of bronchial hyper responsiveness and its downstream respiratory effects [10].

Sleep disorders are a major occupational health concern for firefighters, whose duties involve irregular shift work, frequent night-calls, and high-stress emergency responses [22].

When looking at the global image, one must see that poor sleep quality is mostly encountered in the U.S. ($\approx 73\%$) and Korean ($\approx 49\%$) professional firefighters, possibly as a consequence of shift patterns, secondary employment, and overall workload. Insomnia symptoms affect roughly one-fifth of the French firefighters, aligning with French population estimates of chronic insomnia ($\approx 13\%$) but surpassing rates

observed in some other occupational groups [14].

Sleep disturbances in firefighters are not merely a quality-of-life issue; they have concrete safety ramifications. Prior research links sleep disorders to increased motor-vehicle crashes, occupational injuries, and cardiovascular risk. There are findings that underscore that many sleep problems remain undiagnosed, only 13% reported a known or treated sleep disorder despite the high prevalence of questionnaire-based abnormalities. This under-diagnosis suggests a substantial hidden burden that could impair emergency response performance and elevate accident risk [25].

Given the high prevalence and identifiable risk factors, systematic screening for sleep disorders during periodic medical examinations is warranted. Targeted interventions could include education on sleep hygiene, optimization of shift schedules to reduce night-call frequency, and referral pathways for treatment of anxiety/depression and insomnia [22].

Firefighters operate in one of the most hazardous occupations, facing a spectrum of acute and chronic risks. The probability-severity matrix presented in the study classifies hazards from negligible to maximal, highlighting that many incidents can lead to death. Routine emergencies differ across countries; Romanian units handle 81 % medical assistance, 5 % fires and 14 % other incidents, exposing personnel to diverse threats. Continuous 24-hour shifts disrupt circadian rhythms, forcing rapid transitions from deep sleep to high-intensity activity, which increases accident rates both on-duty and during travel. Over 40 % of U.S. firefighters suffer undiagnosed sleep apnea, and 42 % report sleep disorders, amplifying fatigue-related injuries. Long-term exposure to shift work is linked to metabolic disorders, cardiovascular disease, hypertension, and reproductive dysfunction. Psychological strain is also prevalent; repeated exposure to traumatic

events raises the risk of post-traumatic stress disorder. Moreover, the irregular lighting and noise in resting areas further degrade sleep quality. Implementing regular health monitoring and targeted training can further reduce injury incidence and improve overall wellbeing among fire service members [24].

4. Results and discussions

We presented a systematic synthesis of how shift-work schedules affect firefighters' health and safety, highlighting several key findings. One can clearly confirm that night-shift work disrupts the endogenous circadian clock, leading to sleep-wake misalignment and a cascade of physiological disturbances. These disruptions are linked to elevated risks of cardiovascular disease, metabolic syndrome, gastrointestinal disorders, mental-health problems, and even several cancer types, as documented in the broader literature reviewed.

We also outline preventive and organizational measures. Recommended

ergonomic shift designs include limiting night work, avoiding long sequences of night shifts, preferring fast-forward clockwise rotations, and ensuring adequate rest days after night duties. Health surveillance protocols call for periodic medical checks every 2–3 years, assessing sleep quality; cardiovascular risk factors, metabolic parameters, hormonal status, and psychosocial stressors. Education on sleep hygiene, nutrition, physical activity, and coping strategies, together with organizational interventions such as additional rest breaks, nap opportunities, flexible working-time arrangements, and transport services, are advocated to mitigate fatigue and health risks. The main takeaway from our research is that despite being a necessary way of organizing workplaces, shift-work comes with obvious risks. Moreover, we identified the risks that are more specific to fire-fighters and the consequent recommended measures.

Table 1 Results and discussions

Disruptions	Shift work	Mitigating actions
Cardiovascular disease		Ergonomic shift designs
Metabolic syndrome		Health surveillance protocols
Gastrointestinal disorders		Education on sleep hygiene
Mental-health problems		Nutrition
Cancer		Physical activity

Overall, we underscore that shift-work-induced circadian disruption and associated sleep disorders constitute a critical, modifiable risk factor for both acute safety incidents and long-term chronic diseases among fire fighters. Systematic screening, targeted education, and evidence-based scheduling reforms are presented as essential strategies to protect fire fighters' health while preserving the operational efficiency of round-the-clock emergency services.

5. Conclusions

The study highlights that shift-work profoundly disrupts circadian rhythms, elevating risks of cardiovascular disease, metabolic syndrome, cancer and mental-health disorders, with fire fighters experiencing especially high prevalence of sleep-related problems and respiratory irritation. Systematic screening, ergonomic shift design, regular medical surveillance and targeted education are shown to mitigate these hazards, while specific interventions such as bright-light therapy, melatonin use

and optimized nap opportunities improve sleep quality and operational safety. It is important to stress that poor sleep among fire fighters not only compromises health, but also increases injury and vehicle-crash rates, underscoring the need for organizational policies that limit night-call frequency and promote protective breathing equipment.

Further research directions must look into the reliance on cross-sectional surveys, limited longitudinal data, and a focus on European cohorts and should incorporate diverse populations and long-term outcome tracking in order to provide even more accurate specific data.

References

- [1] Baker S. & Zee P. Circadian disorders of the sleep-wake cycle. In M. H. Kryger, T. Roth, & W. C. Dement (Eds.), *Principles and practice of sleep medicine*. 2000 (3rd ed., pp. 606–614). W.B. Saunders.
- [2] Carter B. D., Diver W. R., Hildebrand J. S., Patel A. V. & Gapstur S. M. Circadian disruption and fatal ovarian cancer. *American Journal of Preventive Medicine*. 2014, 46(3 Suppl 1), S34–S41.
- [3] Chia K. S., Jeyaratnam J., Chan T. B. & Lim T. K. Airway responsiveness of firefighters after smoke exposure. *British Journal of Industrial Medicine*. 1990, 47(8), 524–527.
- [4] Chokroverty S. Diagnosis and treatment of sleep disorders caused by comorbid disease. *Neurology*. 2000. 54(5 Suppl 1), S8–S15.
- [5] Costa G. Shift work and health: Current problems and preventive actions. *Safety and Health at Work*. 2010, 1(2), 112–123. <https://doi.org/10.5491/SHAW.2010.1.2.112>
- [6] Cubillos-Zapata C., Hernandez-Jimenez E., Avendano-Ortiz J., Toledano V., Varela-Serrano A., Fernandez-Navarro I., ... & [Last Author]. Obstructive sleep apnea monocytes exhibit high levels of vascular endothelial growth factor secretion, augmenting tumor progression. *Mediators of Inflammation*, 2018, Article 7373921.
- [7] Darabont D. C., Cioca L.-I., Bejinariu C. & Rosen M. A. (n.d.). Innovations and sustainable practices to ensure project safety and improve risk management capabilities [Special issue announcement]. *Sustainability*. MDPI. <https://mdpi.com/si/210621> page 1 page 2
- [8] Elsenbruch S., Thompson J. J., Hamish M. J., Exton M. S. & Orr W. C. Behavioral and physiological sleep characteristics in women with irritable bowel syndrome. *The American Journal of Gastroenterology*. 2002. 97(9), 2306–2314.
- [9] Graybill N. L., & Weissig V. A review of orexin's unprecedented potential as a novel, highly-specific treatment for various localized and metastatic cancers. *SAGE Open Medicine*. 2017. 5. <https://doi.org/10.1177/2050312117735774>
- [10] Greven F., Krop E., Spithoven J., Rooyackers J., Kerstjens H. & Heederik D. Lung function, bronchial hyperresponsiveness, and atopy among firefighters. *Scandinavian Journal of Work, Environment & Health*. 2011. 37(4), 325–331. <https://doi.org/10.5271/sjweh.3153>
- [11] Howard M. B., Ryan L. M., Psoter K. J., Solomon B. S., Wilson-Lall O. A. & Moon R. Changes in sleep practices during and after illness. *Pediatrics*. 2025. 156, e2025071605. <https://doi.org/10.1542/peds.2025-071605>
- [12] Howard M. B., Ryan L. M., Psoter K. J., Solomon B. S., Wilson-Lall O. A., & Moon R. Knowledge and barriers to safe sleep counseling among pediatric emergency department clinicians and trainees. *The Journal of Pediatrics*. 2026. 290, 114937. <https://doi.org/10.1016/j.jpeds.2025.114937>
- [13] Kales A. & Kales R. *Evaluation and treatment of insomnia*. Oxford University Press 1984.

- [14] Laeger D., Zeghnoun A., Fatraut B. [Other Authors]. Le temps de sommeil, la dette de sommeil, la restriction de sommeil et l'insomnie chronique des 18-75 ans: Résultats du Baromètre de Santé Publique France 2017 [Total sleep time, sleep debt, sleep restriction and insomnia in adults (18-75 years old). Results from the Santé Publique France 2017 Health Barometer]. *Bulletin Épidémiologique Hebdomadaire*, 2019. 149–160.
- [15] Lin X., Chen W., Wei F., Ying M., Wei W. & Xie X. Night-shift work increases morbidity of breast cancer and all-cause mortality: A meta-analysis of 16 prospective cohort studies. *Sleep Medicine*. 2015. 16(11), 1381–1387.
- [16] Moldofsky H. Management of sleep disorders in fibromyalgia. *Rheumatic Disease Clinics of North America*. 2002. 28(2), 173–186.
- [17] Moon R. Y., Mindell J. A., Honaker S., Keim S., Roberts K. J., McAdams R. J. The tension between AAP safe sleep guidelines and infant sleep. *Pediatrics*. 2024. 153, e2023064675. <https://doi.org/10.1542/peds.2023-064675>
- [18] Ohayon M., & Guilleminault C. Epidemiology of sleep disorders. In S. Chokroverty (Ed.), *Sleep disorders medicine*. 1999. (pp. 301–316). Butterworth-Heinemann.
- [19] Otte J. L., Carpenter J. S., Russell K. M., Bigatti S. & Champion V. L. Prevalence, severity, and correlates of sleep-wake disturbances in long-term breast cancer survivors. *Journal of Pain and Symptom Management*. 2010. 39(3), 535–547.
- [20] Partinen M. & Hublin C. Epidemiology of sleep disorders. In M. H. Kryger, T. Roth, & W. C. Dement (Eds.), *Principles and practice of sleep medicine*. 1979. (pp. 558–579). W.B. Saunders.
- [21] Reite M., Ruddy J. & Nagel K. Concise guide to evaluation and management of sleep disorders. American Psychiatric Publishing 2002.
- [22] Savall A., Marcoux P., Charles R., Trombert B., Roche F. & Berger M. Sleep quality and sleep disturbances among volunteer and professional French firefighters: FIRESLEEP study. *Sleep Medicine*. 2021. 80, 228–235. <https://doi.org/10.1016/j.sleep.2021.01.041>
- [23] Silber M. H. Neurologic treatment of sleep disorders. *Neurologic Clinics*. 2001 19(1), 173–186.
- [24] Trefaş L., Trefaş A. S. & Cioca L.-I. Comparative analysis of safety culture in fire fighters from Romania and European countries. *MATEC Web of Conferences*. 2025. 418, 00036. <https://doi.org/10.1051/mateconf/202541800036>.
- [25] Uehli K., Mehta A. J., Miedinger D., Hug K., Schindler C., Holsboer-Trachsler E. ... & Künzli N. Sleep problems and work injuries: A systematic review and meta-analysis. *Sleep Medicine Reviews*. 2014. 18(1), 61–73.
- [26] Walker W. H., II, & Borniger J. C. Molecular mechanisms of cancer-induced sleep disruption. *International Journal of Molecular Sciences*. 2019. 20(11), 2780