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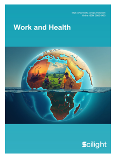

Review

Clues for Occupational Health Surveillance and Epidemiological Research on Night Shift Work from a Scoping Review on Sleep Disruption

Mehreen Aamir [1], Pierluigi Cocco [2,*] and Martie Van Tongeren [2]

[1] Occupational Hygiene Consultant, 4052 Basel, Switzerland
[2] Centre for Occupational and Environmental Health, Division of Population Health, University of Manchester, Oxford Rd., Manchester M13 9PL, UK
* Correspondence: pierluigi.cocco@manchester.ac.uk

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Abstract: Background: Sleep deprivation is a frequent outcome of nightshift work, a probable human carcinogen. However, social, cultural, and technological changes have contributed to spread sleep deprivation also among the general population. We reviewed the literature on sleep disorders in adults associated with lifestyle, environmental, and workplace conditions unrelated to shift work aiming to: 1. identify sleep depriving factors during the pre-placement medical examination of night shift workers; and 2. recognize potential sources of confounding and bias in epidemiological studies of shift workers. Methods: We searched public repositories of publications in English or with an informative English abstract up to January 2024. We used standard tools to assess the quality of the selected studies. Results: Overall, we identified 134 papers. Our review confirms that poor sleep quality and sleep deprivation are highly prevalent and result from multiple non-occupational factors as well as occupational factors other than shift work. Physical activity, coffee and alcohol intake, eating habits, lifestyle, and work-related stress were most frequently investigated (67/134 publications). There is sufficient evidence that aging, female sex, family responsibilities, caffeine intake, smoking, poor mental and physical health, and work-related stress can impair sleep quality and reduce sleep duration. Contradictory findings and the possibility of reverse causation due to the predominance of cross-sectional studies prevent drawing conclusions regarding other potential risk factors. Conclusions: Non-occupational causes of sleep disorders shall be assessed during the pre-placement examination as well as when monitoring the health status of night shift workers or evaluating shift work-related health outcomes.

Keywords: sleep disorders; insomnia; physical activity; work-related stress; social media; 24 h society

1. Introduction

According to the National Sleep Foundation guidelines, 7–9 h of sleep are required to maintain a healthy life [1]. However, In the last decades, the globalization of the world economy, made possible by the technological developments, has trapped the modern society into a 24-h work schedule: not only essential services, such as hospitals, need to run 24 h a day 365 days per year but long-distance travel and communication have also extended social life and work well beyond the sunlight hours, thus compressing the time for rest and sleep. Besides, the need to steal from sleeping time to fulfil family responsibilities, personal habits, and lifestyles, difficulty in maintaining sleep, poor bedroom environment, and habits of taking a daytime nap [2–4] are all deteriorating factors for sleep. The existing evidence supports the deleterious effects on poor sleep quality and reduced sleep duration resulting from such changes [5].

A large body of evidence from experimental animal and human studies has established the link between circadian misalignment and sleep deprivation and immune, inflammatory, and cardiovascular outcomes [6]. Sleep loss, by itself, is associated with an elevated risk of depression, cardiovascular diseases, metabolic syndrome, diabetes, obesity, and overall mortality [7–12]. Moreover, the International Agency for Research on Cancer classified as limited the evidence from human studies for the link between nightshift work and cancer [13]. A possible reason for uncertainty might be the unaccounted confounding by several personal, medical, and lifestyle factors which can also affect sleep [14]. Besides, understanding what non-occupational factors can most likely affect sleep would be important in the pre-placement and workplace surveillance of night shift workers. To address these points, we conducted a scoping review of non-occupational conditions and occupational factors, excluding shift work, associated with sleep disorders in adults. Studies on non-modifiable risk factors, such as the genotype and phenotype (chronotype), are not included in this review.

2. Methods

We conducted a scoping review on the University of Manchester Library Resources, PubMed, and Science Direct databases from the start of registering publications to January 2024 to identify the human studies on sleep deprivation or sleep quality in adults associated with lifestyle or occupational factors excluding shift work. All languages were accepted provided that an informative English abstract was available. Studies of obstructive sleep apnoea and primary sleep disorders were excluded.

The PubMed search was conducted using the following search string: ("Work" [tw] OR "Behavior" [tw] OR "Lifestyle" [tw] OR "Technology" [tw] OR "Hygiene" [tw] OR "Smart Phones" [tw] OR "diet" OR "coffee" OR "caffeine" OR "Physical Health" OR "Mental Health" OR "Fatigue" OR "Metabolic Syndrome" [Mesh] OR "occupational exposure" OR "air pollution" OR "alcohol" OR "smoking" OR "medication" OR "therapy" OR "illicit drugs") AND ("Sleep" [Mesh] OR "Sleep Deprivation" OR "Sleep Loss") AND (Observational study [ptyp] OR "case-control study" OR "cohort study" OR "prospective study" OR "retrospective study" OR "cross-sectional study") NOT (Animals OR Models OR Shift work OR Depression OR COVID OR Sleep Apnea OR Children OR Adolescents OR Students). Depression was excluded from the search string to limit the number of studies with psychiatric issues rather than sleep disorders as the outcome, while allowing depression to be considered among the independent variables. Two co-authors screened each title and abstract to select the relevant papers; disagreements were solved after checking and discussing the full text. We did not perform a formal summary evaluation of the results of the multiple risk factors we analysed. Eight hundred and forty-eight papers were identified through the string search; 735 were discarded as not relevant. Therefore, this review evaluates 126 original papers and eight reviews on specific topics. Figure 1 shows the results of the selection process following the PRISMA guidelines for reporting scoping reviews [15].

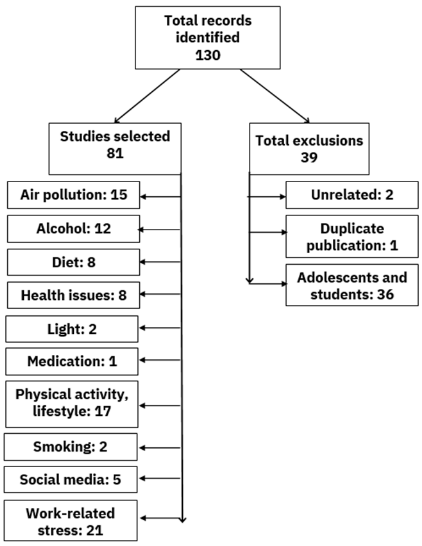

Figure 1. Flow chart of the selection process. The sum of papers for each topic is greater than the total selected papers, as several papers investigated multiple hypotheses.

We assessed the quality of the selected studies with the Critical Appraisal Skill Programme (CASP) checklist, which includes 10 items. Each item scores 2 (yes), 1 (can't tell) or 0 (no). The sum of scores is then categorized in high (18–20), moderate (15–17) or low (less than 15, implying high risk of bias) quality [16].

3. Results

A total of 134 studies were examined. Several studies explored multiple associations; therefore, the overall number of studies is smaller than the sum of those evaluated for each specific risk factor (Figure 1). Most employed a cross-sectional study design, relying on self-reported questionnaire data and a variety of statistical techniques to decipher the connection between the investigated risk factor and sleep deprivation.

The main characteristics of these studies and their results are summarized in Table 1 by risk factor. In the following paragraphs, we examine the results of each risk factor in relation to sleep disorders.

3.1. Air Pollution

Eight studies explored the relationship between air pollution and sleep disorders [17–24]. Three of these examined the use of solid cooking fuel in households [17,18,24], an energy source still popular in some areas of China, India and other middle-low-income countries [25]. Most studies were conducted in rural areas of China. Four were cross-sectional investigations [17,18,21,24], two of which used the Pittsburgh Sleep Quality Index to assess sleep quality [17,18], and the remaining four were ecological studies correlating hospital diagnoses with air monitoring data [19,20,22,23]. Findings were consistently positive across geographic areas and study design [17–24], supporting an association between air pollution and impaired sleep. Overall, the study quality ranged from moderate to good, primarily due to the large sample sizes and robust exposure assessment. Both long-term [19] and short-term [20] indoor concentrations of particulate matter ranging 2.5–10 μm in size, and nitrogen dioxide (NO_2) were associated with poor sleep quality, with risk increasing in parallel with the air concentration [19].

3.2. Alcohol

Fourteen studies have investigated the relationship between alcohol intake and sleep disorders [26–41]. Of these, nine involved human volunteers and were included in a review that found that, among non-alcoholics, even low doses of alcohol can accelerate sleep induction and suppress the REM phase in the initial phase of sleep, followed by a rebound in REM activity during the later stages [26]. In contrast, individuals with alcohol dependence often experience disrupted sleep patterns even after several months of abstinence [26]. A few studies did not observe a relationship between alcohol intake and sleep hours [38–40], while one reported a beneficial effect among women [41].

Most studies employed a cross-sectional design, which raises concerns about reverse causation—namely that individuals with sleeping difficulties might consume alcohol as a remedy. However, four prospective studies were also positive [31,35,37,42]. It is worth noting that definitions of alcohol drinking varied widely across studies, often lacking specificity. Similarly, outcome measures were sometimes limited to broad assessments of sleep problems or disorders, reducing the precision of the findings [29–39].

3.3. Coffee, Caffeinated Beverages and Caffeine in Medications

We retrieved seventeen studies, with the majority (9/17) rated as high quality and the remainder as moderate, primarily due to their cross-sectional design. Ever drinking coffee was associated with a 32% increased risk of insomnia [34], shorter sleep duration [27,43], and a 2.6-fold (95% CI 1.66–3.99) increase in the risk of poor sleep quality [44]. Following adjustments, difficulty maintaining sleep emerged as the most significantly affected parameter [45].

Gender differences were noted: two studies reported stronger effects among women [27,46], while another found no such distinction [41]. The timing of caffeine intake was also crucial. The habit of drinking coffee or tea after dinner or, more broadly, before bedtime, was linked to increased risks of insomnia, short sleep, and poorer sleep quality [33,47,48]. However, a reduction of time spent in bed was observed only among individuals consuming very high amounts of coffee (above 8 cups/day) [49]. Interestingly, those who drank coffee every night before bed reported fewer insomnia symptoms than those who did so once a week [50].

Additional sources of caffeine, such as chocolate, some soda beverages, and medications, also contribute to the overall daily intake [40,44,51,52]. Individuals consuming between 87 and 250 mg of caffeine per day showed a higher prevalence of insufficient sleep and poor sleep quality [53,54]. Among Australian adults, both reduced sleep duration and poorer sleep quality were associated with higher caffeine intake, although caffeine from non-coffee sources did not appear to affect sleep in that study [52].

Contrasting findings emerged from a one-week study that used wrist actigraphy and a daily diary to monitor alcohol, caffeine, and nicotine consumption within four hours of bedtime [42], as well as from research on U.S. veterans with post-traumatic stress disorder [55]. Nonetheless, a systematic review of 24 studies consistently supports a link between excessive coffee and caffeine intake—regardless of the source—and disruptions in sleep onset, maintenance and duration [54].

3.4. Diet and Eating Habits

Considerable heterogeneity exists among the findings of 16 cross-sectional studies on the relationship between diet, eating habits. and sleep [27,39,41,56–68]. The quality of half of these studies was rated as low to moderate, primarily owing to the limitations in the study population selection and inadequate outcome definitions. Lifestyle-related number, timing, and quality of meals have been reported to influence sleep patterns [57,58]. These associations may be influenced by the individual chronotype [59], lifestyle factors, or potentially reflect reverse causation stemming from circadian disruption and resulting sleep disorders.

3.5. Health Disorders

Twenty-one studies have examined the relationship between health disorders and sleep disruption [7,31,32,34,35,37,39,41,47,50,63,68–77]. Of these, nearly three-quarters (14 out of 20) employed a cross-sectional design. Most were of moderate to good quality and consistently reported associations between sleep disturbances and a variety of both mental and physical health conditions. However, findings were less consistent regarding self-reported general ill health [34,50]. In the context of mental disorders, positive associations from cross-sectional studies may arise from the well-known bidirectional relationship linking them with sleep quality and quantity, making it difficult to rule out reverse causation. Short sleep duration is recognized as a chronic stressor [9,42,46,63], and difficulty initiating sleep has been correlated with higher depression scores [72]. Conversely, prospective studies provide robust evidence that depression [37,39,69,71] and other mental disorders [7] can predict the onset of sleep problems in general [71].

Additionally, a range of chronic physical conditions, particularly those involving pain, or impaired breathing have been linked to disrupted and shortened sleep [32–42,48,60–62,67,68,71,74–77].

3.6. Medications

Nine studies have investigated the sleep-disrupting effects of several therapeutic and recreational drugs [41,51,78–84]. With the exception of two high-quality studies, one of which was a randomised trial, and two reviews, the remaining studies were rated moderate to poor in quality due to limitations such as small, non-representative sample sizes, inadequate control of confounders, vague definition of the medications, and potential reverse causation. The latter is particularly relevant in cross-sectional studies involving patients under hypno-inducing treatment. Despite variability depending on the specific compound, dosage, and timing of administration, benzodiazepines and other hypnotics have been shown to cause daytime sleepiness [78] and impair alertness and driving performance during waking hours [79].

Common anti-histaminic medications also reduce daytime vigilance and shorten latency to daytime sleep, while simultaneously increasing latency to night-time sleep onset and REM sleep, and reducing REM sleep duration [80]. Individuals undergoing chronic multipharmacologic therapy have demonstrated shorter sleep duration and lower sleep efficiency as measured by actigraphy [50,81]. A further sleep-disrupting side effect results from caffeinated medications, used in treatments such as spasmolytics or sympathomimetics, posing an additional risk for delayed sleep onset. This effect appears independent of the underlying illness, as similar non-caffeinated drugs did not produce comparable effects [50]. Hormone replacement therapy in postmenopausal women has been associated with a protective effect on sleep [39], which may induce false positive findings if not properly accounted for in the study design.

Recreational drugs, such as heroin, ketamine, and crack-cocaine have also been linked to sleep disruption [82,83]. Notably, users of sleep-promoting drugs reported poor sleep quality and insomnia three times more frequently than non-users, while users of wake-promoting substances also experienced poor sleep but were more prone to fatigue-related errors [84].

3.7. Aging

Five cross-sectional studies and two longitudinal surveys of moderate to high quality have examined the impact of aging on sleep. However, findings across these studies were inconsistent [34,36,39,46,48,85,86]. In contrast, a systematic review and meta-analysis of 252 studies found that sleep problems are highly prevalent among older adults of both sexes living in community dwellings [87].

3.8. Sex and Parenting

Three cross-sectional studies of moderate to high quality and one small, but well-documented prospective trial consistently reported that women are more likely to suffer from insomnia [88–90]. Female executives appear particularly vulnerable to impaired sleep quality when exposed to isolated high-strain occupational environments [90]. Parenting young children, particularly those of pre-school age, is a predictor of insufficient sleep, poor sleep quality, daytime sleepiness, and fatigue. These effects are especially pronounced when caring for children who require medical support [88,89,91].

3.9. Lifestyle

3.9.1. Education and Income

Various lifestyle factors influence both sleep quantity and quality. Specific sections of this review addressed individual habits, such as diet, alcohol consumption, and smoking. In addition, seventeen cross-sectional studies examined other lifestyle dimensions [29,31,33,40,46,49,79,85,86,88,92–98]. The average quality of these reports was moderate, primarily due to potential selection bias.

Higher levels of education and socioeconomic status (SES) were associated with self-reports of better health status and lower stress levels [92]. Such associations appear to be at least partially mediated by improved sleep quality, though not necessarily by sleep duration. Conversely, lower educational attainment was a risk factor for daytime sleepiness among women [49], and the prevalence of good sleepers declined linearly with family income in a Chinese study [79]. However, findings on sleep duration and quality among individuals with lower SES remain inconsistent [31,96], with contrasting results observed between poor countries [93] vs. high-income nations [88]. Several SES-related factors have been identified as independent contributors to poor sleep quality, including time spent at home [94], loneliness, particularly among elderly individuals in rural areas [95,96], limited bedroom space [35], and poor physical, mental, nutritional, and social health [97,98].

3.9.2. Physical Activity

Seventeen studies, including eleven cross-sectional designs, four prospective cohort trials, and one twin study, investigated the relationship between physical activity and sleep quality and/or duration [34,37,39,40,57,68,85,99–108]. Overall, three-quarters of these were rated as high quality. Four studies of moderate to low quality reported shorter sleep duration among elderly individuals engaged in physical activity [39,57,99,100]. In contrast, six high-quality cross-sectional studies [40,68,85,101–103], the four prospective studies, one of which used actigraphic measurements, and the twin study consistently showed a beneficial effect of physical activity on sleep [39,104,106]. While some moderate-poor-quality studies suggested negative outcomes, other well-conducted cross-sectional studies indicated that low to moderate levels of physical activity among older adults may enhance sleep quality and efficiency [37,105,106], potentially through the mediating effect of reduced psychological distress [101]. Furthermore, an intense overall physical activity, combining occupational, leisure time, and household activities, was associated with better sleep outcomes compared to low activity levels [34,85], and may help mitigate the effects of work-related stress [107]. Consistently, sedentary behavior has been identified as a risk factor for short sleep duration [37,68,103,104,108].

3.10. Smoking

Thirteen studies have investigated the association between smoking, reduced sleep duration, and poor sleep quality [34,37,39,40,42,47,57,68,74,75,109–111], and increased frequency of nighttime awakenings [42]. Ten of these employed a cross-sectional design. Overall, the study quality was rated as good in all but three the cross-sectional studies. Findings were mixed. Seven studies, including a well-documented prospective trial [42] and a large biomarker-based survey, reported a significant association between smoking and shorter, lower quality sleep [40,42,57,74,109–111]. The biomarker study also demonstrated a dose-response relationship, with increasing sleep disruption by increasing level of urinary cotinine excretion [111]. In contrast, five studies reported inverse, unclear, or inconsistent results [34,37,39,57,75]. Notably, the association between smoking and sleep disturbances appears to be stronger among women [111].

3.11. Light

Eight studies, mostly cross-sectional and of good methodological quality, examined the impact on sleep of lack of sunlight exposure in the morning and waking before dawn [58,108], or while working [112], blindness [113], and prolonged confinement in isolated, and extreme environments, such as caves, submarines, polar regions, or the International Space Station [114]. Across all contexts, findings consistently indicated an elevated risk of sleep disturbances, particularly insomnia and daytime sleepiness. Reduced exposure to natural sunlight appears to partially explain the poor sleep quality associated with sedentary behaviour [108]. Moreover, both the light spectrum and brightness play a significant role in regulating circadian rhythms and sleep patterns [115–117].

3.12. Use of Social Media and Electronic Devices

Nine cross-sectional studies investigated the association between use of screen-based electronic devices, whether for work or leisure, and sleep disruption in adults [58,118–125]. Half of these studies were rated as moderate in quality due to limitations in the selection of the study population, reliance on self-reported data, and the inherent constraints of the cross-sectional design. Only two studies employed objective measurements and validated tools to assess sleep quality, both of which reported a weak positive association with poor sleep quality [121,124]. Although findings were not entirely consistent, the overall evidence suggests a modest impact of screen use on sleep quality and duration [118–122]. Athletes actively engaged in social media had fewer sleeping hours/night than non-users of social media, although their performance was only minimally affected [123]. The lower exposure to radiofrequency from UMTS phones with respect to GSM did not modify the risk associated with the same time of use [124]. Also, the use of UMTS mobile phones induced minimal changes in the EEG but not sleep stages or sleep quality [125].

3.13. Workplace Factors

Any work-related adverse events may significantly affect family and social life, individual mood, and sleep patterns. This section focuses on five occupational factors unrelated to shift work that may influence sleep quality and quantity: workplace stress, work strain, long working hours, workaholism, and occupational exposure to chemical or physical agents.

3.13.1. Work-Related Stress

Work-related stress was examined in ten studies, most of which were rated as moderate in quality due to limitations in the selection of the study population and outcome measurement [32,39,107,126–132]. All but one employed a cross-sectional design. Despite methodological concerns, these studies consistently reported an association between perceived work-related stress and poor sleep quality, with one study also linking stress to daytime sleepiness. Although it is not always clear whether the impact of shift work was adequately accounted for, evidence from occupational studies suggests that perceived work-related stress directly influences both sleep quality and duration [32,126] in nurses [127], anaesthesiologists [128], academic professors [107], bank employees [129], and professional drivers [39].

A notable source of stress, particularly among healthcare workers and teachers, is violence perpetrated by patients' relatives and students. Such incidents impair professional functioning, induce anxiety, and may compel individuals to alter their behavior or change workplaces [130,131]. The resulting deterioration in sleep quality and increased sleep loss often persists beyond the violent episodes, especially when coupled with unfair managerial practices. On the contrary, a high-justice work environment appears to offer protection against the effects of violence on sleep [127,131]. Following the COVID-19 pandemic, remote work has become increasingly common, particularly among administrative staff. While reduced urban traffic has clear environmental benefits [133], when combined with psychological stress has been associated with a higher incidence of insomnia [132].

3.13.2. Work-Related Strain

Five studies of mixed quality, four cross-sectional [134−137] and one prospective cohort study [138], investigated the association between job strain and sleep disruption. The findings were not entirely consistent. One study employing actigraphy measurements of working hours found a link between extended work hours and poor sleep quality, but no impact on sleep duration [136]. Overall, the inconsistent results, small sample sizes, suboptimal study quality, heterogeneity in the sleep outcome measures, and potential selection bias do not allow reliable conclusions.

3.13.3. Workaholism and Long Working Hours

The term workaholism refers to a personal disposition characterized by compulsive and excessive work engagement. The association between workaholism and/or long working hours with the consequent risk of burnout was specifically examined in five studies: one prospective cohort study [139] and four cross-sectional studies [33,140–143]. Notably, four of these investigations were originally designed for other purposes, introducing a potential risk of bias, where chance positive findings among multiple hypotheses may be given undue weight. Despite the variable outcomes, all studies reported a positive association. The sole prospective cohort study included 1683 survey company monitors who self-defined as workaholics. Findings indicated longer sleep latency and increased daytime dysfunction, but no significant effects on sleep quality, duration, habitual sleep efficiency, sleep disturbance, or use of sleep medication [139].

Although the association was consistently observed, few studies directly focused on this hypothesis. Only one small-scale study incorporated actigraphic measurements, and definitions of sleep outcomes varied across studies. Furthermore, a circular relationship was suggested between long working hours, burnout, and inefficient sleep [142,143]. This complex interplay makes it difficult to rule out reverse causation as a contributing factor to the positive associations detected through cross-sectional investigations.

3.13.4. Occupational Exposure to Chemical and Physical Agents

Workplace exposure to chemical and physical agents may also influence sleep. We identified 12 studies specifically addressing this topic, primarily cross-sectional studies and reviews of published reports [144–155]. Each specific hypothesis was typically tested in only one or two

studies, with considerable variability in quality and often small sample sizes. As a result, while some findings were suggestive and merit replication, they fall short of supporting definitive conclusions.

For example, individuals with sub-acute or chronic antimony poisoning, and those with elevated urinary antimony levels exhibited a 1.7-fold increased risk of sleeping ≤6 h per night (95% CI 1.04–2.91) [144]. Regarding other metals, blood manganese levels showed no clear association with sleep problems [145], and studies on air and blood lead levels reported non-significant links to sleep quality [146]. However, it remains unclear whether night shift workers were excluded from these analyses; avoidance of accounting for night shift work would potentially bias these results.

A review of small-scale studies on the neurotoxic effects of solvents found an association with sleep disruption in 21 out of 24 studies [147]. Similarly, two studies of electric power plant workers reported poorer sleep quality among those chronically exposed to electromagnetic fields (EMF) [148,149], with findings remaining consistent after stratifying by shift work [148].

Environmental conditions such as nighttime temperature and humidity also influence sleep quality [150,151], which in turn affects daytime sleepiness and functional performance [137]. While the importance of optimal indoor temperature and humidity during sleep is well established, less is known about whether and how thermal discomfort in the workplace may interfere with sleep.

A review on the exposure to whole-body vibration (WBV) [152] concluded that WBV increases drowsiness and fatigue, impairs vigilance in drivers, and raises the risk of traffic accidents [152]. However, we found no studies directly linking occupational exposure to hand-arm vibrating tools with sleep disruption.

Exposure to nighttime urban traffic noise is known to cause stress and disturb sleep [153]. Yet, adaptation might mitigate the effects of occupational exposure, as observed in deep-sea fishermen [154]. Notably, unprotected workplace exposure to noise levels exceeding 85 dB was associated with hearing loss, but it apparently impacted sleep quality or quantity [155].

Table 1. Selected studies by cause of sleep loss: study design, source of information, exposure, and outcome. The star symbol (*) indicates the statistical significance of the reported associations. The CASP score is represented with the colour of the leftmost cell: white = low, grey = moderate, black = high probability of bias.

Ref. No.	Authors	Year	Study Size	Country	Study Design	Source of Information	Exposure	Outcome
Air pollution								
[17]	Liao W et al.	2023	28,135	China	Cross-sectional	Questionnaire	Use of solid fuel for cooking	PSQI > 5 *
[18]	Chen G et al.	2019	39,259	China	Cross-sectional	Questionnaire + air monitoring	$PM_{2.5}$, PM_{10}, and NO_2 from use of solid fuel for cooking	PSQI > 5
[19]	Tang M et al.	2020	395,651	China	Ecological study	Hospital records + air monitoring	Residence close to short-term air monitoring stations ($PM_{2.5}$, PM_{10}, NO_2, SO_2, O_3)	Medical diagnosis of a sleep disorder *
[20]	Yu Z et al.	2021	38,775	China	Ecological study	Hospital records + air monitoring + GIS	Residence in proximity to air monitoring stations ($PM_{2.5}$, PM_{10}, NO_2, long-term)	Diagnosis of a sleep disorder *
[21]	Xu J et al.	2021	70,668	China	Cross-sectional	Questionnaire + air monitoring+ GIS	Residence in proximity to air monitoring stations (PM_1, $PM_{2.5}$, PM_{10}, NO_2, O_3)	Insomnia symptoms *
[22]	Tsai LJ et al.,	2022	5108	China-Taiwan	Ecological study	Hospital records + air monitoring+ GIS	Residence in proximity to air monitoring stations ($PM_{2.5}$, NO_2, O_3, long-term)	Diagnosis of a sleep disorder *
[23]	Li D et al.	2022	378,223	United Kingdom	Ecological study	Questionnaire + existing databases	Estimates of generic pollution based on geographic variables	Insomnia symptoms *
[24]	Leng S et al.	2023	60,515	India	Cross-sectional	Questionnaire	Use of solid fuel for cooking	Insomnia symptoms *
Alcohol								
[29]	Bixler EO et al.	1979	1006	U.S.A.	Cross-sectional	Questionnaire	Alcohol intake	Sleep disorders, insomnia
[30]	Kales JD et al.	1984	100/100	U.S.A.	Case-control	Questionnaire	Alcohol intake	Insomnia
[31]	Ford DE, Kamerow DB	1989	7954	U.S.A.	Follow-up	Questionnaire	Alcohol abuse or dependence	Insomnia *
[27]	Kant AK, Graubard BI	2014	15,199	U.S.A.	Cross-sectional	Questionnaire	Alcohol	Sleep duration (NS)
[32]	Kuppermann M et al.	1995	588	U.S.A.	Cross-sectional	Questionnaire	Daily alcohol use	Sleep problems (no ass.)
[33]	Tachibana H et al.	1996	271	Japan	Cross-sectional	Questionnaire	Frequent consumption of alcohol beverages	Insomnia *
[34]	Fabsitz RR et al.	1997	8870	U.S.A.	Twin study	Questionnaire	>12 alcohol drinks/week,	Four sleep problems *
[35]	Katz DA, McHorney CA	1998	1814	U.S.A.	2-year follow-up	Sleep questionnaire	Current or past use of alcohol	Severe-mild insomnia
[36]	Harma M et al.	1998	3020	Finland	Cross-sectional	Questionnaire	Alcohol consumption	Sleep complaints (no ass.)
[37]	Janson C et al.	2001	2602	Sweden	Longitudinal survey	Questionnaire	Alcohol dependence,	Insomnia *
[38]	Nishitani N et al.	2013	274	Japan	Cross-sectional	Questionnaire	Alcohol	Sleep duration Upward trend
[39]	Hege A et al.	2019	260	U.S.A.	Cross-sectional	Questionnaire	Alcohol	Sleep duration and quality *
[40]	Martins Teixeira C et al.	2023	6356	Brazil	Cross-sectional	Questionnaire	Alcohol	Sleep time (NS)
[41]	Jaussent I et al.	2011	9294	France	Cross-sectional	Questionnaire	Alcohol intake in women	Short sleep duration (inv. ass.)
[42]	Spadola CE et al.	2019	785	U.S.A.	Longitudinal survey	Actigraphy and sleep diary	Alcohol,	Sleep efficiency *

Table 1. *Cont.*

Ref. No.	Authors	Year	Study Size	Country	Study Design	Source of Information	Exposure	Outcome
Alcohol								
[48]	Chaput et al.	2012	703	Canada	Cross-sectional	Questionnaire	Alcohol consumption	Sleep duration *
Coffee, caffeinated beverages and medications								
[27]	Kant AK, Graubard BI	2014	15,199	U.S.A.	Cross-sectional	Questionnaire	Coffee	Sleep duration *
[33]	Tachibana H et al.	1996	271	Japan	Cross-sectional	Questionnaire	Coffee before going to bed	Insomnia *
[34]	Fabsitz RR et al.	1997	8870	U.S.A.	Twin study	Questionnaire	Coffee intake	Four sleep problems *
[39]	Hege A et al.	2019	260	U.S.A.	Cross-sectional	Questionnaire	Caffeine consumptions'	Sleep duration and quality *
[40]	Martins Teixeira C et al.	2023	6356	Brazil	Cross-sectional	Questionnaire	Coffee	Sleep time *
[41]	Jaussent I et al.	2011	9294	France	Cross-sectional	Questionnaire	Coffee	Sleep abnormalities
[42]	Spadola CE et al.	2019	785	U.S.A.	Longitudinal survey	Actigraphy and sleep diary	Coffee ≤ 4 h before bedtime	Sleep efficiency (NS)
[43]	Marcus GM et al.	2023	100	U.S.A.	Prospective randomized trial	Actigraphy, intervention protocol	Coffee intake	Sleep duration *
[44]	Jemilohun AC et al.	2022	505	Nigeria	Cross-sectional	Questionnaire	Coffee	Sleep quality *
[45]	Chaudhary NS et al.	2016	4730	U.S.A.	Cross-sectional	Questionnaire	Coffee intake	Insomnia symptoms *
[46]	Baker FC ert al.	2009	959	U.S.A.	Cross-sectional	Questionnaire	Caffeinated beverages	Sleep quality *, daytime sleepiness
[47]	Getachew Y et al.	2020	421	Nigeria	Cross-sectional	Questionnaire	Coffee	Poor sleep quality *
[49]	Sanchez-Ortuno M et al.	2005	1498	France	Cross-sectional	Questionnaire	≥8 cups of coffee daily	Sleep duration *
[50]	Al Karaki G et al.	2020	756	Lebanon	Cross-sectional	Questionnaire	Coffee before going to bed	Insomnia
[51]	Brown SL et L.	1995	2885	U.S.A.	Cross-sectional	Questionnaire	caffeine from beverages and medications (≥87 mg/day)	Sleep complaints
[52]	Watson EJ et al.	2016	80	Australia	Cross-sectional	Questionnaire	Caffeinated beverages	Sleep quality *
[53]	Tesfaye AH et al.	2023	370	Nigeria	Cross-sectional	Questionnaire	Caffeine (≥250 mg/day)	Sleep quality *
[54]	Gardiner C et al.	2023	-	-	Review	24 published reports	Coffee intake	Sleep problems *
[55]	McLean CP et al.	2019	366	U.S.A.	Cross-sectional	Questionnaire	Caffeine	Sleep quantity and quality (no ass.)
Diet and eating habits								
[27]	Kant AK, Graubard BI	2014	15,199	U.S.A.	Cross-sectional	Questionnaire	Food items, coffee	Sleep duration *

Table 1. *Cont.*

Ref. No.	Authors	Year	Study Size	Country	Study Design	Source of Information	Exposure	Outcome
Diet and eating habits								
[39]	Hege A et al.	2019	260	U.S.A.	Cross-sectional	Questionnaire	Eating habits	Sleep duration and quality *
[41]	Jaussent I et al.	2011	9294	France	Cross-sectional	Questionnaire	Food intake	Sleep abnormalities
[56]	Rontoyanni VG et al.	2007	30	Greece	Cross-sectional	Questionnaire	Energy, saturated fat intake	Sleep duration *
[57]	De Castro MA et al.	2019	1081	Brazil	Cross-sectional	Questionnaire	Meals' number and timing, energy intake	Sleep duration *
[58]	Shimura A et al.	2020	5640	Japan	Cross-sectional	Questionnaire	Unhealthy eating and drinking habits, irregular meal times.	Sleep disturbances *
[59]	Rosi A et al.	2022	95	Italy	Cross-sectional	Questionnaire	Chronotype, meal timing	Sleep duration & PSQI ≥ 5 (no ass.)
[60]	Papadopoulou SK et al.	2023	3405	Greece	Cross-sectional	Questionnaire, clinical exam	Nutritional status	PSQI ≥ 5 *
[61]	Ogilvie RP et al.	2018	1854	U.S.A.	Cross-sectional	Questionnaire	Regular breakfast and meals, Mediterranean, traditional diet	Better sleep quality and duration
[62]	Gaona-Pineda EB et al.	2021	6511	Mexico	Cross-sectional	Questionnaire	Dietary pattern	OSA, sleep duration, insomnia, daytime sleepiness
[63]	Wang S et al. (1)	2017	4115	China	Cross-sectional	Questionnaire	Diet in elderly	Sleep duration *
[64]	Mondin TC et al.	2019	1903	Australia	Cross-sectional	Questionnaire	Diet quality score (DQS)	Sleep duration: direct association with DQS
[65]	Kinugawa A et al.	2023	1311	Japan	Cross-sectional	Questionnaire	Diet with low fruit	Insomnia *
[66]	Hashimoto A et al.	2020	80	Japan	Cross-sectional	Questionnaire + actigraph data	Energy and dietary nutrients	Sleep efficiency *
[67]	Theorell-Haglöw J et al.	2020	23,829	Sweden	Cross-sectional	Questionnaire	Health diet score (modified Mediterranean score)	Sleeping < 6 h: * (inv. ass.)
[68]	Wang S et al. (2)	2017	17,320	China	Cross-sectional	Questionnaire	Irregular meal pattern	Short sleep duration*
Health disorders								
[7]	Song HT et al.	2015	149	China	Cross-sectional	Questionnaire	Cortisol level, mania	Sleep deprivation *
[31]	Ford DE, Kamerow DB	1989	7954	U.S.A.	Follow-up	Questionnaire	Depression	Insomnia *
[32]	Kuppermann M et al.	1995	588	U.S.A.	Cross-sectional	Questionnaire	General ill health	Sleep problems (no ass.)
[34]	Fabsitz RR et al.	1997	8870	U.S.A.	Twin study	Questionnaire	11 morbid condistions	Four sleep problems *
[35]	Katz DA, McHorney CA	1998	1814	U.S.A.	2-year follow-up	Sleep questionnaire	Physician-diagnosed multimorbidities	Severe-mild insomnia
[37]	Janson C et al.	2001	2602	Sweden	Longitudinal survey	Questionnaire	Mental health, back pain	Insomnia *
[39]	Hege A et al.	2019	260	U.S.A.	Cross-sectional	Questionnaire	Mental health diagnosis	Sleep duration and quality *

Table 1. *Cont.*

Ref. No.	Authors	Year	Study Size	Country	Study Design	Source of Information	Exposure	Outcome
Health disorders								
[41]	Jaussent I et al.	2011	9294	France	Cross-sectional	Questionnaire	Poor health,	Sleep abnormalities
[47]	Getachew Y et al.	2020	421	Nigeria	Cross-sectional	Questionnaire	Depression	Poor sleep quality *
[50]	Al Karaki G et al.	2020	756	Lebanon	Cross-sectional	Questionnaire	Chronic diseases	Insomnia
[63]	Wang S et al. (1)	2017	4115	China	Cross-sectional	Questionnaire	Mental health, multimorbidity	Sleep duration *
[68]	Wang S et al. (2)	2017	17,320	China	Cross-sectional	Questionnaire	Mental health, multimorbidity	Sleep duration *
[69]	Nishitani N et al.	2019	1258	Japan	Follow-up	Questionnaire	Depression	Insomnia *
[70]	Nakata A et al.	2004	1940	Japan	Cross-sectional	Questionnaire	Depressive symptoms, Stress	Insomnia *
[71]	Luik AI et al.	2024	4007	The Netherlands	Prospective trial	Questionnaire, health history	Mental health	Insomnia *
[72]	Ikeda H et al.	2017	1184	Japan	Cross-sectional	Questionnaire	Depression score	Difficulty in initiating sleep
[73]	Choi D.-W. et al.	2018	67,425	South Korea	Cross-sectional	Questionnaire	Stress awareness	Short sleep duration *
[74]	Knapik JJ et al.	2023	20,819	U.S.A.	Cross-sectional	Questionnaire + medical database	Multiple morbidities, mental health	Sleep duration ≤ 4 h *
[75]	Riedel BW et al.	2004	769	U.S.A.	Cross-sectional	Questionnaire	Gastrointestinal problems	Total sleep time *
[76]	Gaudin RA et al.	2017	104	Germany	Cross-sectional	Questionnaire	allergic rhinitis	Poor sleep quality *
[77]	Adejumo OA et al.	2023	307	Nigeria	Cross-sectional	Questionnaire	Chronic kidney disease	PSQI ≥ 5 (no ass.)
Medication								
[41]	Jaussent I et al.	2011	9294	France	Cross-sectional	Questionnaire	Sleep medication, hormone replacement therapy (HRT)	Insomnia symptoms; HRT (inv. ass.)
[51]	Brown SL et L.	1995	2885	U.S.A.	Cross-sectional	Questionnaire	Caffeinated medications	Sleep complaints
[78]	Nishino S & Mignot E	1999	NA	U.S.A.	Review	Review of the literature	Hypnosedatives and CNS stimulants	Insomnia, excessive daytime sleepiness
[79]	Verster JC et al.	2004	NA		Review	Review of the literature	Benzodiacepin hypnotics, zolpidem, zaleplon	Driving ability
[80]	Boyle J et al.	2006	18	Japan	Randomized trial	Polisomnography	Chlorpheniramine and fexofenadine	Sleep latency, REM sleep *
[81]	Zambrin Campanini M et al.	2021	168	Brazil	Cross-sectional	Questionnaire, actigraph data	Continuous use of ≥ 3 medications	PSQI ≥ 5 *
[82]	Tang J et al.	2015	2178	China	Cross-sectional	Questionnaire	Detoxification treatment	PSQI ≥ 5 *
[83]	Hess ARB, de Almeida RMM	2015	46	Brazil	Cross-sectional	Questionnaire in clinical setting	Crack-cocaine	Sleep problems

Table 1. *Cont.*

Ref. No.	Authors	Year	Study Size	Country	Study Design	Source of Information	Exposure	Outcome
Medication								
[84]	Ogeil RP et al.	2019	377	Australia	Cross-sectional	Interview	Various illicit drugs and medications	Sleep quality, insomnia, errors *
Aging								
[31]	Bixler EO et al.	1979	1006	U.S.A.	Cross-sectional	Questionnaire	Aging	Prevalence of sleep disorders, insomnia
[35]	Tachibana H et al.	1996	271	Japan	Cross-sectional	Questionnaire	Aging	Insomnia *
[37]	Katz DA, McHorney CA	1998	1814	U.S.A.	2-year follow-up	Sleep questionnaire	Advanced age	Severe-mild insomnia
[39]	Janson C et al.	2001	2602	Sweden	Longitudinal survey	Questionnaire	Aging	Insomnia (no ass.)
[41]	Jaussent I et al.	2011	9294	France	Cross-sectional	Questionnaire	Aging	Insomnia (no ass.)
[46]	Baker FC ert al.	2009	959	U.S.A.	Cross-sectional	Questionnaire	Menopause	Sleep quality *, daytime sleepiness
[85]	Li J et al.	2018	290	China	Cross-sectional	Questionnaire	Aging	Bad sleeping
[86]	Schoenborn CA et al.	2013	76,669	U.S.A.	Cross-sectional	Questionnaire	Aging	Sleep duration *
[87]	Canever JD	2014	NA	-	Review	252 worldwide studies	Aging	Sleep problems
Sex and parenting								
[88]	Skinner N et al.	2015	573	Australia	Cross-sectional	Telephone survey	Parenting, working > 45 h/wk	Insufficient sleep, fatigue *
[89]	Lecca R et al.	2023	156	Italy	Cross-sectional	Questionnaire	Female sex	Sleep quality *
[90]	Gadinger MC et al.	2009	424	Germany, Austria, Switzerland	Cross-sectional	Questionnaire	Female sex	Sleep quality
[91]	Keilty K et al.	2018	85	Canada	Prospective trial	Actigraph data, sleep diary, questionnaire	Caregiving to children	Daytime sleepiness *, poor sleep quality *, fatigue *.
Lifestyle, education, income								
[29]	Bixler EO et al.	1979	1006	U.S.A.	Cross-sectional	Questionnaire	Low socio-economic status (SES)	Prevalence of sleep disorders, insomnia
[31]	Ford DE, Kamerow DB	1989	7954	U.S.A.	Follow-up	Questionnaire	Low education and SES	Insomnia *
[33]	Tachibana H et al.	1996	271	Japan	Cross-sectional	Questionnaire	Limited space in bedroom	Insomnia *
[40]	Martins Teixeira C et al.	2023	6356	Brazil	Cross-sectional	Questionnaire	Occupational status	Short sleep time *
[46]	Baker FC ert al.	2009	959	U.S.A.	Cross-sectional	Questionnaire	Low education	Daytime sleepiness
[85]	Li J et al.	2018	290	China	Cross-sectional	Questionnaire	Low income, poor education	Bad sleeping
[86]	Schoenborn CA et al.	2013	76,669	U.S.A.	Cross-sectional	Questionnaire	Education, poverty, marital status	Sleep duration *

Table 1. *Cont.*

Ref. No.	Authors	Year	Study Size	Country	Study Design	Source of Information	Exposure	Outcome
Lifestyle, education, income								
[88]	Skinner N et al.	2015	573	Australia	Cross-sectional	Telephone survey	Parenting, working > 45 h/wk	Insufficient sleep, fatigue *
[92]	Moore PJ et al.	2002	1139	U.S.A.	Cross-sectional	Questionnaire	Socio-economic status	Sleep quantity, quality *
[93]	Singh EI, Vitzthum VJ	2019	73	Guyana	Cross-sectional	Questionnaire	Poverty	Sleep duration *
[94]	Jalali N et al.	2022	481	U.S.A.	Cross-sectional	Sensor activation	Time spent at home	Sleep duration *
[95]	Peng A et al.	2021	11,196	China	Cross-sectional	Questionnaire	Loneliness	Sleep latency *, PSQI ≥ 5 *
[96]	Jia G, Yuan P	2020	1658	China	Cross-sectional	Questionnaire	Loneliness	PSQI ≥ 5 *
[97]	Abdelaziz EM et al.	2022	410	Saudi Arabia	Cross-sectional	Medical records	Health promoting lifestyle	Sleep quality *
[98]	Tadayon M et a.	2019	70	Iran	Cross-sectional	Questionnaire	Lifestyle	Sleep quality *
Physical activity								
[34]	Fabsitz RR et al.	1997	8870	U.S.A.	Twin study	Questionnaire	Physical activity	Four sleep problems (inv. ass.) *
[37]	Janson C et al.	2001	2602	Sweden	Longitudinal survey	Questionnaire	Physical inactivity	Insomnia *
[39]	Hege A et al.	2019	260	U.S.A.	Cross-sectional	Questionnaire	Exercise	Sleep duration and quality *
[40]	Martins Teixeira C et al.	2023	6356	Brazil	Cross-sectional	Questionnaire	Physical activity	Sleep time (inv. ass.) *
[57]	De Castro MA et al.	2019	1081	Brazil	Cross-sectional	Questionnaire	Physical activity	Sleep duration *
[68]	Wang S et al. (2)	2017	17,320	China	Cross-sectional	Questionnaire	Lack of physical exercise	Short sleep *
[85]	Li J et al.	2018	290	China	Cross-sectional	Questionnaire	Physical activity	Sleep quality * (inv.ass.)
[99]	Litleskare S et al.	2018	3763	Norway	Cross-sectional	Questionnaire	Intermediate exercise level	Sleep quality *
[100]	García-Soidán JL et al.	2014	99	Spain	Cross-sectional	Questionnaire, accelerometer	Pilates exercise	Sleep quality *
[101]	Yamamoto Y	2015	108	Japan	Cross-sectional	Accelerometer, questionnaire	Physical activity, sedentary behaviour	Sleeping time
[102]	Leitaru N et al.	2019	2765	Sweden	Cross-sectional	Questionnaire	Low-level physical activity	poor sleep quality *
[103]	Gubelmann C et al.	2018	2649	Switzerland	Cross-sectional	Questionnaire	Physical activity	Insomnia * Short sleep (no ass.)
[104]	Hidaka T et al.	2020	49,483	Japan	Prospective cohort study	Physical activity	Physical activity	Sleep quality (men) *
[105]	Kimura N et al.	2020	855	Japan	Prospective cohort study	Interview, actigraph data, physical exam, cognitive assessment	Daily walking steps	Sleeping hours *, sleep efficiency *
[106]	Tsunoda K et al.	2015	14,446	Japan	Prospective cohort study	Questionnaire	Physical activity	Sleep duration and efficacy
[107]	Macedo Carvalho Freitas A et al.	2020	423	Brazil	Cross-sectional	Questionnaire	physical activity	Sleep quality *

Table 1. *Cont.*

Ref. No.	Authors	Year	Study Size	Country	Study Design	Source of Information	Exposure	Outcome
Physical activity								
[108]	Alves de Menezes MA	2023	1629	Brazil	Cross-sectional	Questionnaire	Sedentary behaviour, sunlight	Sleep quality
Smoking								
[34]	Fabsitz RR et al.	1997	8870	U.S.A.	Twin study	Questionnaire	Smoking	Inverse association with sleep problems
[37]	Katz DA, McHorney CA	1998	1814	U.S.A.	2-year follow-up	Sleep questionnaire	Advanced age	Severe-mild insomnia
[39]	Hege A et al.	2019	260	U.S.A.	Cross-sectional	Questionnaire	Smoking	Perceived job stress
[40]	Martins Teixeira C et al.	2023	6356	Brazil	Cross-sectional	Questionnaire	Smoking	Short sleep *
[42]	Spadola CE et al.	2019	785	U.S.A.	Longitudinal trial	Actigraphy and sleep diary	Smoking	Low sleep efficiency *
[47]	Getachew Y et al.	2020	421	Nigeria	Cross-sectional	Questionnaire	Smoking	Poor sleep quality *
[57]	De Castro MA et al.	2019	1081	Brazil	Cross-sectional	Questionnaire	Smoking	Sleep duration *
[68]	Wang S et al. (2)	2017	17,320	China	Cross-sectional	Questionnaire	Smoking	Long sleep *
[74]	Knapik JJ et al.	2023	20,819	U.S.A.	Cross-sectional	Questionnaire + medical database	Smoking	Sleep duration ≤ 4 h *
[75]	Riedel BW et al.	2004	769	U.S.A.	Cross-sectional	Questionnaire	Smoking	Inconsistent association with sleep variables
[109]	Mehari A et al.	2014	4979	U.S.A.	Cross-sectional	Interview + clinical examination	Smoking	Short sleep *, poor quality sleep *
[110]	Woo DH et al.	2023	174,665	Korea	Cross-sectional	Questionnaire	Smoking	PSQI ≥ 5 *
[111]	Zandy M et al.	2020	10,806	Canada	Cross-sectional	Quest. + biomarkers	Urinary cotinine	Sleep problems *
Light								
[58]	Shimura A et al.	2020	5640	Japan	Cross-sectional	Questionnaire	Lack of sunlight exposure	Sleep disturbances *
[108]	Alves de Menezes MA	2023	1629	Brazil	Cross-sectional	Questionnaire	Sunlight	Sleep quality
[112]	Leger D et al.	2011	13,296	France	Cross-sectional	Questionnaire, lux meter	Lack to sunlight exposure	Insomnia *, daytime sleepiness *
[113]	Sack RL et al.	1992	20	U.S.A.	Cross-sectional	Plasma melatonin and cortisol	Blind people	Insomnia, daytime sleepiness
[114]	Zivi P et al.	2020	-	-	Review	Published reports	Isolated, confined, extreme environments	Sleep disturbances
[115]	Viola AU et al.	2008	94	United Kingdom	Cross-sectional	Lighting modulation during daytime, questionnaire	Blue-enriched light	Daytime sleepiness, sleep quality
[116]	Ishizawa M et al.	2021	11	Japan	Cross-sectional	Questionnaire, personal light recorder	Blue light exposure in pre-bedtime	Decrease in deep sleep *
[117]	Amdisen L et al.	2022	317	Denmark	Cross-sectional	Questionnaire, personal light recorder	Exposure to different spectra during the day	Decrease in the deep sleep ratio *

Table 1. *Cont.*

Ref. No.	Authors	Year	Study Size	Country	Study Design	Source of Information	Exposure	Outcome
Use of social media and electronic devices								
[58]	Shimura A et al.	2020	5640	Japan	Cross-sectional	Questionnaire	In bed use of electronic devices, TV at night.	Sleep disturbances *
[118]	Custers K, Van den Bulck J	2012	711	Belgium	Cross-sectional	Questionnaire	Use of TV, access to Internet	Bedtime *, sleep duration *
[119]	Xie WJ et al.	2020	1500	China	Cross-sectional	Questionnaire	TV, smartphone, Internet use	PSQI ≥ 5 *
[120]	Bhat S et al.	2018	855	U.S.A.	Cross-sectional	Questionnaire	use of social media before sleep	Insomnia, short sleep duration
[121]	Grimaldi-Puyana M et al.	2020	306	Spain	Cross-sectional	Questionnaire, smartphone apps	Smartphone use	PSQI ≥ 5 *
[122]	Andersen LL, Garde AH	2015	7883	Denmark	Cross-sectional	Questionnaire	Computer use during leisure time	Sleep problems *
[123]	Watkins RA et al.	2022	40	U.S.A.	Cross-sectional	Questionnaire	Use of social media	Sleep quality
[124]	Tettamanti G et al.	2020	21,049	Sweden, Finland	Cross-sectional	Questionnaire, operator-recorded mobile phone use	Mobile phone use, exp. to radiofrequency	Sleep quality (NS)
[125]	Lowden A et al.	2019	18	Sweden	Cross-sectional	Polysomnography, RF measurements, EEG	UMTS mobile phone use, exp. to radiofrequency	Sleep parameters (no. ass.)
Work-related stress								
[32]	Kuppermann M et al.	1995	588	U.S.A.	Cross-sectional	Questionnaire	Work-related stress	Sleep problems (no. ass.)
[39]	Hege A et al.	2019	260	U.S.A.	Cross-sectional	Questionnaire	Work-related stress	Perceived job stress
[107]	Macedo Carvalho Freitas A et al.	2020	423	Brazil	Cross-sectional	Questionnaire	High psychological demand	Sleep quality *
[126]	Deng X et al.	2020	155	China	Cross-sectional	Questionnaire	Stress score	Sleep quality score *
[127]	Lonnqvist K et al.	2023	632	Finland	Cross-sectional	Questionnaire	Job demand, job control, procedural, interactional, and distributive justice	Sleep quality *
[128]	Valente F et al.	2019	256	Portugal	Cross-sectional	Questionnaire	Perceived stress scale	Sleep quality *
[129]	Motohashi Y, Takano T	1995	148	Japan	Cross-sectional	Questionnaire	Perceived stress scale	Sleep disturbances *
[130]	Bezerra de Castro Alves Silveira F et al.	2021	286	Brazil	Cross-sectional	Questionnaire, mortality data	Stress from violence at work	Sleep latency *
[131]	Gluschkoff K et al.	2017	4988	Finland	Prospective cohort study	Questionnaire	Violence at work, procedural justice	Disturbed sleep *
[132]	Matsumoto Y et al.	2023	2971	Japan	Cross-sectional	Questionnaire	Stress, remote working	Sleep quality *
Work-related strain								
[134]	Schierolz RS et al.	2019	84	Germany	Cross-sectional	Questionnaire	Job strain	Sleep quality NS Daytime sleepiness *
[135]	Kunzweiler K et al.	2016	153	Germany	Cross-sectional	Questionnaire	Unequal distribution of work	Sleep quality *

Table 1. *Cont.*

Ref. No.	Authors	Year	Study Size	Country	Study Design	Source of Information	Exposure	Outcome
Work-related strain								
[136]	Kubo T et al.	2016	39	Japan	Cross-sectional	Questionnaire, actigraph data	Work time control	Sleep efficiency *
[137]	Mokarami H et al.	2020	90	Iran	Cross-sectional	Questionnaire, measurements	Job control	Day time sleepiness *
[138]	Jiang Y et al.	2021	4169	China	Prospective cohort study	Questionnaire	Work-related stress, coping resources	Sleep quality *
Workaholism and long working hours								
[33]	Tachibana H et al.	1996	271	Japan	Cross-sectional	Questionnaire	long working hours	Insomnia *
[139]	Kubota K et al.	2014	1683	Japan	Prospective cohort study	Questionnaire	Workaholism	Prolonged sleep latency *
[140]	Suresh S et al.	2022	1521	India	Cross-sectional	Questionnaire	Working hours	Insomnia *
[141]	Kubo T et al.	2021	58	Japan	Cross-sectional	Questionnaire actigraph data	Working overtime	Sleep quality *
[142]	Lin RT et al.	2021	2081	China-Taiwan	Cross-sectional	Questionnaire	Working hours, burnout	Sleeping hours *
Occupational exposure to chemical and physical agents								
[144]	Scinicariello F et al.	2017	2654	U.S.A.	Cross-sectional	Questionnaire, air and urine monitoring data	Air and urinary antimony level	Sleep problems, * daytime sleepiness *
[145]	Yang C-L et al.	2024	8356	U.S.A.	Cross-sectional	Questionnaire, blood monitoring data	Blood manganese	Sleep problems (no. ass.)
[146]	Mohammadyan M et al.	2019	47	Iran	Cross-sectional	Questionnaire, air and blood monitoring data	Air and blood lead level	Poor sleep quality (NS)
[147]	Viaene M et al.	2009	-	-	Review	24 published reports	Exposure to solvents at work	Sleep problems
[148]	Liu H et al.	2014	854	China	Cross-sectional	Questionnaire	Self-reported exposure to electromagnetic fields	Poor sleep quality *
[149]	Hosseinabadi MB et al.	2019	275	Iran	Cross-sectional	Questionnaire, EMF measurements	EMF (chronic exposure)	Poor sleep quality *
[150]	Quinn A, Shaman J	2017	40	U.S.A.	Cross-sectional	Microclimate measurements, questionnaires	Microclimate	Sleep quality and quantity *
[151]	Okamoto-Mizuno K et al.	2005	8	Japan	Experimental trial	Polysomnography, monitoring body temperature, EEG	Body temperature	Wakefulness, sleep parameters
[152]	Bhuiyan MHU et al.	2022	-	-	Review	12 published reports	Whole body vibration	Drowsiness *
[153]	Stansfeld S	2000	-	-	Review	Unspecified number of published reports	Daytime and night time exposure to noise	REM sleep reduction, generic sleep disturbances
[154]	Abrahamsen AS et al.	2023	150	Faroe Islands	Cross-sectional	Vibration & noise measurements, sleep diary, actigraphy	Whole body vibration, noise, days at sea, catch volume	Sleep efficiency, fatigue, sleepiness
[155]	Rios AL, Alves Da Silva G	2005	40	Brazil	Cross-sectional	Audiometry, polysomnography	Noise level ≥ 85 dB	Sleep quality and quantity (no ass.)

Note: * significant association; NS non-significant association; no ass. lack of an association: inv. ass inverse association (protective effect).

4. Discussion

Our scoping review identified 12 non-occupational conditions and five workplace factors unrelated to shift work that may influence sleep. The non occupational conditions examined included air pollution, particularly from indoor use of solid cooking fuels, alcohol consumption, smoking, caffeine intake, dietary habits, family responsibilities, sex, aging, health disorders, light exposure, medication use, lifestyle and physical activity, and social media use. Based on the available evidence, several factors appear to be more consistently associated with sleep disturbances. These include pre-existing mental and physical health issues, especially when accompanied by chronic pain or respiratory difficulties, female sex, family responsibilities (notably among women caring for small children or elderly relatives), exposure to intense light or specific wavelengths that disrupt the natural light/dark cycle, smoking, and stressful working conditions unrelated to shift work. These factors should be systematically considered during the pre-placement evaluations for candidates applying to night shift jobs. They should be incorporated into informational and educational programs for night shift workers, and regularly monitored through workplace health surveillance. Furthermore, their potential role as confounders or sources of bias must be carefully addressed in studies of nightshift workers. In the following paragraphs, we will explore additional insights into the other risk factors associated with sleep disorders.

4.1. Air Pollution

The incomplete combustion of solid fuels releases fine particulate matter with an aerodynamic diameter around 2.5 µm ($PM_{2.5}$), nanoparticles, carbon monoxide, and black carbon, key constituents of household air pollution. Fine particulates can penetrate deep into the lungs, leading to mucociliary dysfunction and impaired immune responses. Carbon monoxide reduces the oxygen-carrying capacity of hemoglobin [25], while nanoparticles are capable of crossing cellular membranes, entering the bloodstream and reaching any organ [156]. Air pollution has been linked to oxidative stress and inflammation, and although the underlying mechanisms remain unclear, it may impair central nervous system functions, including the regulation of circadian rhythms, thereby contributing to insomnia [157]. Outdoor air pollution has also been positively associated with sleep disruption [19,24,137]. However, the reliability of these findings is limited by methodological concerns, including the so-called ecological fallacy, cross-sectional study designs, and potential publication bias. When considering the mechanism by which indoor air pollution may affect sleep, most attention has been directed toward fine particulate matter (PM_1, $PM_{2.5}$ and PM_{10}), NO_2, sulphur dioxide (SO_2), and ozone (O_3) [18–22], and the associated oxidative stress, chronic inflammation, and potential disruption of the circadian rhythms through largely unknown pathways. However, we propose that a more plausible contributor could be the concurrent exposure to carbon monoxide in poorly ventilated environments. This exposure may lead to elevated levels of carboxyhemoglobin and reduced arterial oxygen saturation, a mechanism reminiscent of the frequent awakenings observed in obstructive sleep apnea. The use of solid fuels should therefore be investigated as a potential factor in sleep disruption, particularly among night shift workers in regions where such fuels are commonly used.

4.2. Alcohol

The effects of alcohol on sleep are multifaceted and complex. Consequently, findings on its sleep-disrupting impact have been inconsistent, varying according to the daily amount and timing of consumption. Within the first hour after intake, low doses of alcohol tend to have stimulating effects, prolonging sleep onset latency. A few hours later, as blood alcohol levels decline, both low and high doses exhibit sedative properties that initially promote sleep and suppress the REM phase. This is followed by a rebound in REM activity, increased arousal episodes, and sleep fragmentation [26,28]. Even when consumed several hours before bedtime, when alcohol's blood level has returned to zero, alcohol can still disrupt sleep, suggesting the presence of long-lasting effects. Chronic intake and high alcohol consumption have been associated with the development of insomnia [28,48]. The sedative effect of alcohol is thought to result from its facilitation of GABAergic inhibitory neurotransmission and inhibition of other neurotransmitters, such as the N-methyl-D-aspartate (NMDA**)** glutamate receptor and adenosine [26]. While alcohol may initially facilitate sleep initiation, this effect tends to diminish after a few days of continuous use [28].

Nonetheless, consistent epidemiological evidence indicates that alcohol consumption may shorten sleep, and contribute to insomnia [27,28,158]. Alcoholism, mental disorders, and sleep problems frequently co-occur [28], and alcohol use is more likely to precipitate depression than vice versa [159]. To date, the potential modifying or confounding role of mental disorders in the relationship between alcohol intake and sleep disturbances remains underexplored. Further research with clearly defined exposure and outcome measures is essential to elucidate this association.

4.3. Coffee, Caffeinated Beverages and Caffeine in Medications

The relationship between caffeine consumption through beverages and medications and sleep disruption appears to be more consistent than that of other substances. Although some studies reported contradictory findings, such as no effect from the late evening coffee intake [42,50], no association with insomnia [54], or effects only at very high doses [49], these inconsistencies may be attributable to increased caffeine tolerance linked to specific gene polymorphisms [160,161]. Coffee is commonly used to enhance daytime alertness and mitigate circadian misalignment among nightshift workers [162,163], which may, in turn. contribute to reduced sleep duration during daytime rest periods. Therefore, when assessing sleep disruption in shift workers, it is essential to account for the potential confounding influence from excessive caffeine intake.

4.4. Diet and Eating Habits

A preference for high-fat food may explain the elevated prevalence of obesity among individuals experiencing sleep deprivation [164]. In women, body fat was found to increase by 2.8% for each one-hour redusction in nocturnal sleep, after adjusting for age and energy intake. Moreover, sleep duration was significantly correlated with saturated fat intake, but not with total energy intake or a general preference for fats or carbohydrates [56]. The observed association between body mass index and difficulty initiating sleep may also reflect reverse causation [41].

Additional studies have shown that the number, quality, and timing of meals influence the nature and strength of the association with sleep duration. Specifically, evening snacks, but not energy intake at dinner, were inversely associated with sleep duration [57,58]. Interestingly, a small cross-sectional study found that meal timing and food preferences at dinner varied by the chronotype, whereas sleep habits did not [59]. This raises questions about whether the chronotype or meal timing and quality directly affect sleep quality and duration. Nonetheless, several lifestyle and dietary factors appear to support better sleep outcomes. These include dedicating at least one hour per day to cooking and/or eating [39], maintaining a good nutritional status [60], consuming regular breakfasts [61] and meals [27], and adhering to Mediterranean [41] or traditional [62] dietary patterns. Overall, a balanced diet is associated with improved sleep quality and a sleep duration of seven hours or more per night [59–66].

4.5. Health Disorders

Adverse mental effects, and particularly depression, often arise from chronic stress [67]. Insomnia has been identified as a significant predictor of work-related stress, especially in the context of workplace conflicts, dissatisfaction, and depressive symptoms [68]. For example, elevated serum cortisol levels, a biomarker of stress, have been correlated with sleep deprivation and, among sleep-deprived individuals, with scores predictive of various mental disorders [7]. Among older adults, both short and long sleep durations have been associated with an increased risk of poor mental health [60]. These findings raise questions about whether the relationship between sleep disturbances and mental health is direct, mediated by aging. or influenced by differences in mental health conditions between elderly and working-age populations.

Regarding physical health, allergic rhinitis has shown a significant correlation with poor sleep quality, even after adjusting for age, sex, smoking status, and asthma [76]. In contrast, the association between chronic kidney disease and poor sleep quality vanished in multivariable analyses after adjusting for anxiety, depression, and overall quality of life [77].

4.6. Medications

A substantial proportion of the general population in Europe and the United States uses hypnosedatives [165]. Although a decreasing trend had been reported [166], this was disrupted by the COVID-19 lockdown, particularly among older adults [167]. The impact of sleep-inducing and wake-promoting medications, antihistamines, and illicit drugs on sleep quality and duration is greater among night shift workers, who may rely on these substances more frequently to enhance alertness during work hours or facilitate sleep during daytime rest periods. A thorough health history is essential to disentangle the effects of these substances from those of the underlying medical conditions and from sleep disturbances directly related to circadian disruption.

4.7. Sex

Only a few studies have examined sex differences in the risk of insomnia and sleep disorders. Nevertheless, findings consistently indicate that women are more frequently affected. Responsibilities such as caring for young children or disabled relatives often fall disproportionately on women, potentially contributing to reduced sleep quality and duration, as shown in a small prospective trial [91]. Given that women constitute the majority of the workforce in many essential occupations, further research into the social and biological factors underlying this increased vulnerability is critically important.

In the meantime, regardless of whether this predisposition stems from environmental, cultural, or psychological pressures disproportionately affecting women, or from biological factors that heighten their susceptibility to insomnia, health surveillance of female night shift workers warrants extra attention and care.

4.8. Lifestyle and Physical Activity

Various conditions associated with low socio-economic status may negatively impact both sleep quality and duration. However, in some studies, the ability to draw firm conclusions is limited by factors such as cross-sectional study designs, small sample sizes, potential selection bias, and inconsistent associations observed between low- and high-income countries.

An active lifestyle is closely related to good nutritional status and overall quality of life, of which high-quality sleep is a key component [60]. Evidence from both cross-sectional and prospective studies indicates that any level of physical activity can enhance sleep quality and duration, a finding of particular importance in aging populations. Future research should investigate whether physical activity may also help improve sleep quality and support adaptation among night shift workers.

4.9. Smoking

Although findings are not always consistent, robust mechanistic evidence supports a link between smoking and reduced sleep duration and quality. Nicotine promotes the release and bioavailability of neurotransmitters, such as dopamine, serotonin, epinephrine, glutamate, and acetylcholine, resulting in heightened arousal and wakefulness. Notably, 41% of heavy smokers report nocturnal smoking, often triggered by nighttime nicotine withdrawal and frequent awakenings due to cravings [111]. This may be partly explained by reduced dopamine transport [168] in the striatal region of the smoker's brain [169].

Current evidence suggests that smokers who work night shifts have an additional reason to be discouraged from maintaining their habit, given its compounding effects on sleep disruption. From an epidemiological standpoint, studies on the health outcomes of night shift work should account for smoking as a confounding factor, due to its higher prevalence among night shift workers [170].

4.10 Light

The internal clock, and consequently the sleep/wake cycle, is regulated by the natural alternation of light and darkness. During the day, outdoor light intensity can range between 1000 to 25,000 lux, depending on latitude and climate, whereas standard indoor lighting typically falls between 50 and 500 lux [171]. Although the underlying mechanisms are complex and not yet fully understood, current evidence supports a true association between light exposure and sleep regulation.

Daytime exposure to artificial bright and blue-enriched light in the workplace has been shown to enhance sleep quality, alertness, and cognitive performance compared to standard white light [115]. In contrast, pre-bedtime exposure to blue light reduces the proportion of deep sleep relative to exposure to incandescent light or the use of blue light-blocking glasses [116]. At night, blue light also suppresses melatonin secretion, delays sleep onset, and disrupts the circadian phase [112]. Moreover, exposure to artificial light spectra that differ from natural sunlight in the morning may amplify the disruptive effects of light exposure in the evening [117]. These findings suggest that the timing and quality of light exposure throughout the day play a critical role in sustaining alertness and preserving sleep propensity during rest periods. This has important implications for promoting circadian adaptation among shift workers, for whom strategic light exposure could serve as a valuable tool in managing sleep-wake disturbances.

4.11. Use of Social Media and Electronic Devices

The use of screen-based electronic media devices during nighttime hours is likely to contribute to sleep disturbances [33,119], potentially due to blue light emission (~450 nm), which is a potent inhibitor of melatonin synthesis [171]. However, this hypothesis requires further investigation through more rigorous and methodologically robust studies to establish a clearer causal relationship.

4.12. Work-Related Stress

Work-related stress is often conceptualized through the effort-reward imbalance model, which posits that stress arises when there is a lack of reciprocity between the efforts invested in work and the rewards received, such as financial compensation, esteem, and career advancement opportunities (e.g., promotion and job security) [172]. Occupations characterized by high effort and low reward are associated with psychobiological stress responses and long-term adverse health outcomes. Additionally, conflicts between work demands and family responsibilities, particularly among women [173], may hinder the fulfilment of legitimate expectations, leading to frustration, mood disturbances, and sleep disruption.

An alternative framework attributes work-related stress to the inter psychosocial job characteristics, including job demand, job control, and perception of procedural, interactional, and distributive justice. Within this model, profiles marked by high job strain (i.e., high demand couple with low control) and low workplace justice have been consistently associated with poorer sleep quality [127,172].

Although the overall quality of most studies in this area is moderate, limiting the strength of conclusions, the hypothesis of a connection between work-related stress and sleep disruption remains plausible. Accordingly, workplace interventions should aim to alleviate stress-inducing conditions, whether stemming from occupational or non-occupational sources, whenever feasible.

4.13. Work-Related Strain

Few studies have examined the impact of job strain on sleep. Work-related strain is typically assessed through three scales: cognitive irritation, emotional irritation, and global irritation. Higher scores across all three dimensions have been directly correlated with the Epworth Sleepiness Scale (ESS), suggesting insufficient sleep and increased daytime somnolence [134]. Among individuals who self-reported poor health status, job strain was associated with a two-fold increased risk of poor sleep quality [103].

One contributing factor to workplace conflict and stress is the unequal distribution of workload, which has also been linked to diminished sleep quality [135]. Conversely, organizational strategies that grant employees greater control over their work schedules have demonstrated improvements in performance, as measured through psychomotor vigilance tasks, and in sleep efficiency assessed via actigraphy, although no significant changes were observed in sleep quality or duration [136].

In contrast, heightened work stressors, including high role overload, increased responsibility, adverse physical work environments, and reduced self-care and coping resources [136], along with low job-control, have been shown to elevate the risk of sleep disturbances in both sexes [137]. Notably, reducing work stressors appeared to be protective against sleep disturbances in women but not in men, while the combination of diminished coping resources and increased work stressors posed the greatest risk [138].

4.14. Workaholism and Long Working Hours

Workaholics often fail to allocate sufficient time for recovery from fatigue, which is likely to impact sleep. Regardless of other covariates, excessive job involvement and long working hours have been consistently associated with self-reported insomnia [33,140] and poor sleep quality objectively measured with actigraphy [141]. Moreover, prolonged working hours contribute to burnout, primarily through the intermediary effect of sleep loss [142], a leading predictor of burnout [143]. Long-working hours have also been linked to increased coffee consumption [37], which may further impair sleep quality and introduce unaccounted bias in related studies.

To better understand the relationship between workaholism, extended working hours, and sleep disorders, further prospective studies with adequate statistical power are needed.

4.15. Occupational Exposure to Chemical and Physical Agents

A limited number of studies have investigated specific workplace exposures, such as metals, solvents, and non-ionizing radiation, in relation to sleep disruption. Positive associations have been reported for exposure to antimony [144], solvents [147], and EMF [148,149]. While findings are intriguing, the evidence remains sparse, and the possibility of publication bias cannot be ruled out.

Cooling of the body and brain temperature typically occurs during non-rapid eye movement (NREM) sleep episodes. In preparation for this phase, all animal species exhibit thermoregulatory behaviors, such as nest building and curling up [174]. Consequently, the indoor microclimate, including air temperature, humidity, and airflow, is critical for ensuring sleep comfort and quality.

Noise exposure can also impact sleep, likely through increased catecholamine secretion [175]. However, it remains unclear whether chronic workplace exposure to noise contributes to long-term sleep disturbances.

5. Conclusions

Multiple factors may contribute to sleep disturbances and complicate job pre-placement evaluations, health surveillance, and research on nightshift workers. Evidence highlights the influence of aging, female sex, family responsibilities, caffeine consumption, smoking, poor mental and physical health, and work-related stress. Whenever feasible, these factors should be systematically considered during pre-placement assessments, monitored throughout periodic health surveillance, and appropriately accounted for when examining the causal relationship between night shift work and its potential health outcomes.

Author Contributions

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