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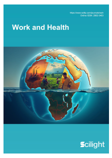

Article

Association of Obstructive Sleep Apnea Risk with Occupational Accidents in Rotating Night Shift Textile Workers

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Abstract: Obstructive Sleep Apnea (OSA) represents a critical yet often underdiagnosed contributor to occupational morbidity, given its established links to impaired vigilance, neurocognitive dysfunction, and accident proneness. This cross-sectional study evaluated the prevalence of OSA risk and its relationship with occupational accidents among rotating shift workers. Between April and June 2024, 217 textile workers underwent assessment using the STOP-BANG questionnaire (score ≥3 indicating OSA risk) alongside the Epworth Sleepiness Scale, Pittsburgh Sleep Quality Index, and Insomnia Severity Index. Compared with their counterparts, those at risk were older, had higher body mass index, larger neck and waist circumferences, longer employment duration, more comorbidities, and higher daytime sleepiness scores (ESS: 4 [0–11] vs. 5 [0–16]; $p = 0.007$), while subjective sleep time and sleep quality indices were comparable. In total, 36.4% of workers reported an occupational accident in the past year. Accident prevalence was higher in those with OSA risk (50.0% vs. 28.1%), and OSA risk remained an independent predictor of accidents (adjusted OR = 2.55; 95% CI: 1.44–4.53; $p = 0.001$) in the fully adjusted model. These findings highlight OSA as a prevalent, underrecognized determinant of occupational safety among shift workers. Integrating systematic OSA screening into workplace health surveillance and implementing targeted preventive measures could mitigate accident risk, improve productivity, and contribute to a closer alignment between sleep medicine and occupational health practice.

Keywords: obstructive sleep apnea; occupational accident; daytime sleepiness; sleep apnea screening; STOP-BANG

1. Introduction

OSA is a sleep disorder characterized by recurrent episodes of partial or complete upper airway obstruction during sleep, leading to intermittent hypoxemia, hypercapnia, and sleep fragmentation [1]. These physiological disturbances result in excessive daytime sleepiness, impaired concentration, and prolonged reaction times, which may increase the likelihood of both traffic and workplace accidents [2]. Among individuals diagnosed with OSA, the incidence of occupational accidents is significantly higher [3].

Shift work refers to a work schedule in which employees succeed one another to ensure continuous operation. This form of work organization is particularly common in the healthcare, security, transportation, manufacturing, and energy sectors [4]. The International Labour Organization (ILO) defines several types of shift systems, including rotational shifts in which workers alternate between day, evening, and night duties [5].

Because of the misalignment between working hours and the body's circadian rhythm, shift work may cause sleep disturbances and other adverse health effects. These negative outcomes become more pronounced when workers perform consecutive night shifts with limited recovery periods, leading to circadian rhythm disruption, reduced sleep quality, and prolonged wakefulness. Consequently, attention lapses, delayed reaction times, and microsleep episodes may occur, increasing the risk of occupational and traffic accidents [6]. Previous research has shown that night-shift workers experience higher rates of attention lapses and performance errors than day workers [7], and that the risk of occupational accidents increases with longer shift durations [6].

Recent evidence suggests that shift work and obstructive sleep apnea can coexist, although existing studies report heterogeneous findings regarding the association between the two conditions [8]. Circadian misalignment caused by irregular work–sleep schedules can worsen upper airway instability and sleep fragmentation, while intermittent hypoxia and sleep disruption in OSA may further destabilize circadian regulation and impair alertness [9]. The coexistence of these two conditions therefore poses a substantial risk to occupational safety, particularly in industries requiring sustained attention and rapid psychomotor responses.

Within this context, the textile industry represents an important segment of the global manufacturing workforce and is characterized by continuous production processes, high labor intensity, and widespread implementation of rotating shift systems. Textile workers commonly perform repetitive, safety-sensitive tasks under time pressure and physical workload, often in environments requiring sustained attention and vigilance. These organizational and task-related features make this occupational group particularly vulnerable to sleep disturbances and fatigue-related safety risks. Despite this, textile workers remain underrepresented in sleep health research compared with other shift-working populations such as healthcare workers or professional drivers. Investigating obstructive sleep apnea risk and occupational accidents in this setting therefore provides valuable insight into sleep-related safety challenges in industrial shift work more broadly.

In this study, we aimed to investigate the relationship between OSA risk and the occurrence of occupational accidents among rotating night-shift textile workers.

2. Materials and Methods

2.1. Study Design and Population

This study employed a cross-sectional design to evaluate participants with respect to the risk of OSA, while occupational accident data were retrospectively reviewed. Information on accident history was obtained through self-report and covered incidents that occurred after the initiation of shift work within the past year after the initiation of shift work.

The study population consisted of production-line workers employed under a rotating shift system in a textile factory. The shift schedule followed a morning–evening–night rotation, with each 8-h shift worked for six consecutive days, followed by a 24-h rest period before transitioning to the next shift. Accordingly, each worker was assigned to a night shift approximately once every 15 days. All workers adhered to the same roster pattern.

2.2. Definition of Occupational Accident

Occupational accidents were defined according to the ILO framework and included workplace accidents during working hours, work-related transport accidents, and commuting accidents [10]. The definition encompassed any occupational accident regardless of injury severity. Information regarding medical consultation, workers' compensation claims, or days of work missed was not collected. Occupational accident history was obtained through self-report during structured interviews; information from company records or administrative databases was not available in the study setting.

2.3. Inclusion and Exclusion Criteria

Workers aged 18–65 years, employed in a rotational shift system for at least three months, literate, and who provided written informed consent were included. Exclusion criteria were use of sedative medication or psychoactive substances, known neurological or severe psychiatric disorders, and pregnancy.

2.4. Data Collection Tools

Data were collected through a structured questionnaire assessing sociodemographic, occupational, and lifestyle characteristics. Four validated instruments were applied to evaluate OSA risk and sleep characteristics: the STOP-BANG Questionnaire, the Epworth Sleepiness Scale, the Pittsburgh Sleep Quality Index, and the Insomnia Severity Index.

2.5. STOP-BANG Questionnaire

The STOP-BANG Questionnaire, comprising eight dichotomous items, was used to screen for OSA risk. It includes both subjective and objective components such as snoring, tiredness, observed apnea, hypertension, body mass index, age, neck circumference, and sex [11]. A total score of ≥3 was considered indicative of increased OSA risk.

2.6. Epworth Sleepiness Scale (ESS)

Excessive Daytime Sleepiness (EDS) was evaluated through the ESS [12,13]. Participants rated the likelihood of dozing in eight routine situations on a 0–3 scale, yielding a total score between 0 and 24. Scores of ≥11 indicated increased daytime sleepiness.

2.7. Pittsburgh Sleep Quality Index (PSQI)

Subjective sleep quality was assessed using the PSQI [14,15], which measures seven components of sleep: subjective quality, latency, duration, habitual efficiency, disturbances, medication use, and daytime dysfunction. Each component is scored 0–3, providing a global score between 0 and 21. A total score >5 indicates poor sleep quality.

2.8. Insomnia Severity Index (ISI)

Insomnia severity was evaluated using the ISI [16,17], a seven-item instrument assessing the nature, severity, and impact of insomnia symptoms over the previous two weeks. Each item is rated from 0 (none) to 4 (very severe), producing a total score between 0 and 28. Participants scoring ≥8 were classified as having clinically significant insomnia symptoms.

2.9. Variables

The dependent variable was the presence of an occupational accident. Independent variables included age, sex, body mass index (BMI), neck and waist circumference, marital status, number and age of children, smoking and alcohol use, tea and coffee consumption, total years of employment, comorbidities, STOP-BANG score, ESS score, PSQI score, and ISI score.

2.10. Statistical Analysis

Descriptive statistics were expressed as number (n) and percentage (%) for categorical variables, and as mean, standard deviation, median, minimum, and maximum for continuous variables. The Kolmogorov–Smirnov test and skewness–kurtosis values were used to assess normality. For normally distributed data, the independent samples *t*-test was applied; for non-normally distributed data, the Mann–Whitney U or Kruskal–Wallis test (with Bonferroni correction) was used. Correlations between parameters were examined using Spearman's correlation coefficient.

Univariable logistic regression analyses were initially performed to explore associations between potential risk factors and occupational accidents. To minimize multicollinearity, variables that are components of the STOP-BANG questionnaire (age, sex, body mass index, neck circumference, and blood pressure–related comorbidities) were not considered separately in the multivariable analysis. Instead, OSA risk assessed by the composite STOP-BANG score was prioritized.

Multivariable analysis was subsequently conducted using a forward stepwise logistic regression approach (Likelihood Ratio method), including smoking status, psychotropic drug use, caffeine consumption, total duration of work, comorbidities, ESS, ISI, PSQI, and OSA risk as candidate variables.

Odds ratios (ORs) with 95% confidence intervals (CIs) were calculated by exponentiating the regression coefficients. A p-value ≤ 0.05 was considered statistically significant. Analyses were performed using IBM SPSS Statistics version 27.0 (IBM Corp., Armonk, NY, USA).

2.11. Ethics Approval Statement

The study protocol was approved by the Ethics Committee of the Faculty of Medicine, Ege University (approval date: 8 February 2024; approval number: 24-2T/27). The study was conducted in accordance with the principles of the Declaration of Helsinki.

3. Results

3.1. *Study Population and OSA Risk Distribution*

A total of 263 workers were assessed for eligibility, of whom 217 met the inclusion criteria and formed the final study population (Figure 1).

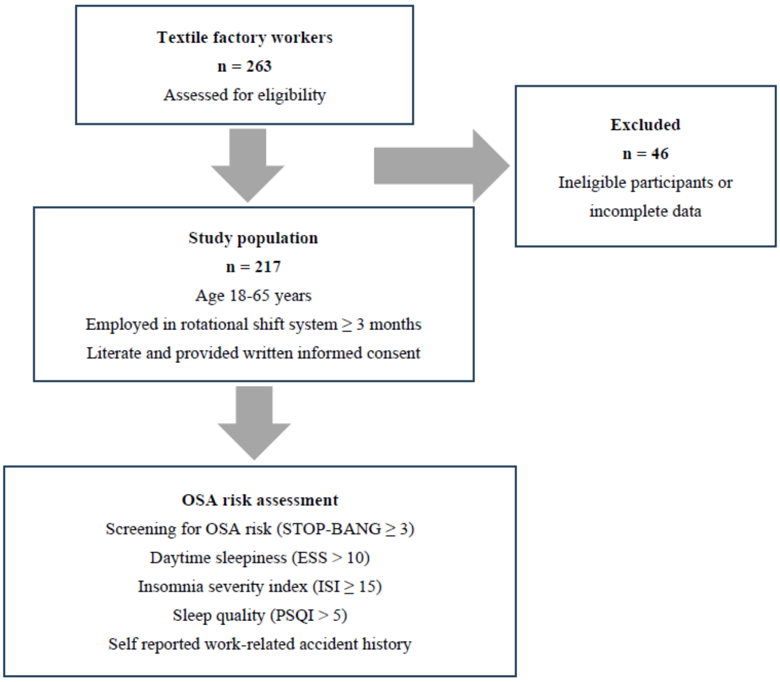

Figure 1. Flowchart of the study.

Based on STOP-BANG scores, 82 participants (37.8%) were classified as being at risk for OSA, while 135 (62.2%) were not. Overall, 79 workers (36.4%) reported at least one occupational accident within the past year. The proportion of workers reporting an accident was notably higher among those with OSA risk (50.0%) compared with those without OSA risk (28.1%)—Table 1.

Table 1. Comparison of demographic, clinical, and work-related characteristics between workers with and without risk of OSA based on STOP-BANG score.

Variable	No OSA Risk STOP-BANG < 3 (n = 135)	OSA Risk STOP-BANG ≥ 3 (n = 82)	*p*-Value *
Age (yrs)	32 (20–55)	35.5 (21–58)	**0.005**
Sex, n (%)			
Female	13 (9.6)	3 (3.6)	0.103
Male	122 (90.4)	79 (96.4)	
BMI (kg/m^2)	24.6 (17.9–32.2)	28.6 (17.9–41.3)	**<0.001**
Neck circumference (cm)	39 (28–45)	43 (32–49)	**<0.001**
Waist circumference (cm)	91 (63–113)	101 (63–134)	**<0.001**
Marital status, n (%)			0.150
Single/Divorced	49 (36.2)	22 (26.8)	
Married	86 (63.8)	60 (73.2)	
Smoking (pack-years)	5.0 (0–45)	2.75 (0–45)	0.222
Alcohol consumption (unit)	0 (0–16.1)	0 (0–9.2)	0.493
Psychotropic drug use, n (%)			0.139
Yes	2 (1.4)	4 (4.8)	
No	133 (98.6)	78 (95.2)	
Tea/coffee consumption, caffeine (mg)	300 (0–1120)	250 (0–1120)	0.104
Total duration of work (yrs)	7 (1–32)	9 (1–35)	**0.014**
Comorbidities, n (%)			**0.006**
Yes	13 (9.6)	19 (23.1)	
No	122 (90.4)	63 (76.9)	

Table 1. *Cont.*

Variable	No OSA Risk STOP-BANG < 3 (n = 135)	OSA Risk STOP-BANG ≥ 3 (n = 82)	*p*-Value *
Occupational accidents, n (%)			**0.001**
Yes	38 (28.1)	41 (50)	
No	97 (71.9)	41 (50)	
ESS	4 (0–11)	5 (0–16)	**0.007**
ISI	4 (0–22)	6.5 (0–23)	0.055
PSQI	5 (1–14)	5 (1–13)	0.649
Poor sleep quality, n (%)			0.500
Yes	53 (39.2)	36 (43.9)	
No	82 (60.8)	46 (56.1)	
Subjective sleep time (min)	385 (170–720)	420 (220–600)	0.295
Subjective sleep latency, n (%)			0.337
≥30 min	60 (44.4)	31 (37.8)	
<30 min	75 (55.6)	51 (62.2)	

Abbreviations: ESS, Epworth Sleepiness Scale; ISI, Insomnia Severity Index; PSQI, Pittsburgh Sleep Quality Index. Values are presented as median (range) or n (%). * Bold *p*-values indicate statistical significance ($p < 0.05$).

3.2. *Comparison of Workers With and without OSA Risk*

Workers with OSA risk were significantly older (median 35.5 vs. 32 years, $p = 0.005$) and had higher body mass index (28.6 vs. 24.6 kg/m^2, $p < 0.001$), larger neck circumference (43 vs. 39 cm, $p < 0.001$), and greater waist circumference (101 vs. 91 cm, $p < 0.001$) than those without OSA risk. The total duration of employment was longer among workers with OSA risk (median 9 vs. 7 years, $p = 0.014$). The prevalence of comorbidities was also higher in this group (23.1% vs. 9.6%, $p = 0.006$).

Regarding sleep-related measures, participants with OSA risk showed higher ESS scores (median 5 vs. 4, $p = 0.007$). However, there were no significant differences in ISI, PSQI, subjective sleep duration, or sleep latency (all $p > 0.05$). (Table 1)

3.3. Univariable Associations with Occupational Accidents

In univariable logistic regression analyses, several demographic, anthropometric, clinical, and sleep-related variables were associated with occupational accident risk (Supplementary Table S1). Workers at risk for OSA had significantly higher odds of occupational accidents compared with those without OSA risk (unadjusted OR = 2.55, 95% CI: 1.44–4.53; $p = 0.001$). Associations were also observed for age and anthropometric measures, including body mass index, neck circumference, and waist circumference.

3.4. Multivariable Analysis of Factors Associated with Occupational Accidents

In the final multivariable model, only OSA risk (STOP-BANG ≥ 3) remained independently associated with occupational accidents (adjusted OR = 2.55, 95% CI: 1.44–4.53; $p = 0.001$), while all other candidate variables did not meet the criteria for retention in the final model (Table 2).

Table 2. Multivariable (forward stepwise LR) logistic regression analysis of factors associated with occupational accidents.

Variable	Exp(B)	Lower	Upper	*p*-Value
Obstructive sleep apnea risk	2.55	1.44	4.53	0.001

Abbreviation: Exp(B), exponentiated regression coefficient.

Forward stepwise (Likelihood Ratio) logistic regression analysis was performed. Candidate variables entered into the stepwise procedure included smoking status, psychotropic drug use, caffeine consumption, total duration of work, comorbidities, ESS, ISI, PSQI, and OSA risk. Only OSA risk met the criteria for inclusion and was retained in the final model.

4. Discussion

Our study examined the association between OSA risk and occupational accidents among rotating-shift textile workers. Based on STOP-BANG scores, over one-third of workers were classified as being at risk for OSA, and OSA risk independently increased the likelihood of workplace accidents. In the context of the forward-rotating shift system examined in this study, the textile workforce represents a broader group of industrial shift workers exposed to continuous production demands, rotating schedules, and safety-critical tasks, enabling our findings to inform occupational sleep health and accident-prevention strategies beyond the textile sector.

The frequency of OSA risk observed in our study falls within the 9–38% range reported in the general population [18], however, sleep disorders have consistently been shown to be more prevalent among night-shift workers than among non–shift-working populations [19], suggesting that occupational factors related to shift work may play an important role in shaping OSA risk. Although the biological mechanisms linking OSA to accident risk are well established, the scientific contribution of the present study lies in its contextual and occupational focus. Rotating-shift textile workers constitute a large industrial workforce that has received limited attention in occupational sleep health research. Their work is characterized by continuous production demands, prolonged night work, and repetitive tasks requiring sustained vigilance, conditions that may amplify the safety consequences of untreated OSA. In the setting of this study, sleep disorders such as OSA are not routinely incorporated into standard occupational health surveillance practices. Examining OSA risk-related accident risk in this group therefore provides relevant evidence on sleep-related safety risks in industries operating under rotating shift schedules.

Recent studies demonstrate a bidirectional interaction between OSA and circadian rhythm disruption, both of which are prevalent among shift-working populations. Circadian misalignment resulting from irregular light–dark exposure, sleep restriction, and altered meal timing promotes metabolic dysregulation, weight gain, and hypertension increasing susceptibility to OSA [9]. In shift-working settings, chronic circadian disruption may therefore contribute to the development and progression of OSA by promoting adverse metabolic profiles.

Our findings align with this conceptual framework. In our study population, workers at risk for OSA demonstrated significantly higher BMI, neck, and waist circumference values, as well as a higher prevalence of comorbidities. Although these anthropometric predictors are well-recognized determinants of OSA in the general population, their prominence in this relatively young, rotating-shift workforce suggests an occupational contribution. Circadian misalignment and irregular meal timing associated with shift work may promote metabolic alterations such as weight gain, visceral fat accumulation, and hypertension, thereby aggravating the structural and physiological factors that predispose to OSA. Longer employment duration observed among high-risk workers may also reflect the cumulative metabolic burden of chronic shift work exposure.

In addition to these circadian mechanisms, the organization of shift schedules may also influence how strongly sleepiness is expressed in different occupational settings. The workers in our study followed a forward-rotating schedule, which aligns better with the natural circadian rhythm and is considered less disruptive. In comparison, aeronautical maintenance technicians working a regular backward-rotating pattern (four consecutive workdays followed by two days off, rotating from night to evening to morning shifts) have been reported to show substantially higher ESS scores, even more than untreated OSA patients, highlighting how certain rotation systems can intensify daytime sleepiness even when clinically evident sleep-disordered breathing is not present [20]. The relatively small difference in ESS scores between OSA-risk groups in our sample may therefore be related to the lower circadian strain created by forward rotation.

In our study, workers at risk for OSA had higher ISI scores than those without OSA risk, indicating more pronounced insomnia symptoms in this group. This finding aligns with previous evidence showing that OSA and insomnia frequently coexist, a condition known as Comorbid Insomnia and Sleep Apnea (COMISA) [21]. In OSA, nocturnal arousals and sympathetic activation can contribute to difficulty maintaining sleep and nonrestorative sleep quality, which may help explain this overlap [22]. Among shift workers, irregular sleep–wake schedules and circadian misalignment may further worsen these symptoms by disturbing normal sleep timing and reducing the ability to achieve consolidated sleep. Therefore, insomnia in shift-working individuals with OSA risk likely reflects the combined impact of both physiological sleep disruption and disrupted circadian regulation. Recognizing this overlap is important for workplace screening and prevention strategies aimed at reducing fatigue and accident risk.

The independent association between OSA risk and accident risk was particularly notable, with workers at risk for OSA experiencing approximately a 2.5-fold increase in accident likelihood which is consistent with prior evidence linking OSA to higher rates of traffic and workplace injuries [3,23]. Similar findings have been reported in professional drivers; in-city bus drivers at high risk for OSA based on the Berlin Questionnaire showed increased accident rates compared with low-risk drivers [24]. Intermittent hypoxemia and sleep fragmentation—two central features of OSA—are well-established causes of impaired sustained attention, slower reaction times, and reduced psychomotor vigilance [25,26]. In our study, however, ESS scores differed only modestly between workers with and without OSA risk, suggesting that subjective sleepiness may underestimate the functional impact of OSA in this setting. In this context, evidence indicates that a substantial proportion of patients with polysomnography-confirmed OSA report little or no excessive daytime sleepiness, highlighting the limitations of ESS in capturing the full functional impact of the disease [27]. In line with this, objective performance studies show that neurocognitive deficits can persist even when self-reported daytime sleepiness is mild, as many individuals with clinically relevant OSA do not perceive themselves as sleepy despite measurable impairments in vigilance and reaction time [28]. Brief microsleep episodes may also occur without awareness, further increasing the risk of safety-critical errors [29].

The small differences in ESS, ISI, and PSQI scores between workers with and without OSA risk may be related to the fact that all participants were exposed to rotating shift work. Rotating shifts are associated with chronic circadian disruption and sleep restriction, which can increase baseline levels of sleep disturbance and fatigue across the entire workforce and limit the ability of subjective sleep questionnaires to distinguish between groups. In addition, sleep measures based on self-report in occupational settings may be affected by normalization of symptoms or underreporting, as workers may be hesitant to report sleepiness or insomnia in a work-related context. Consequently, subjective sleep scales may be less sensitive to group differences in such settings, even when underlying risk profiles differ. Within this context, OSA risk may represent an additional and independent contributor to accident risk, acting on top of shift work–related sleep disturbance rather than through a simple linear pathway mediated by subjective sleep scales.

Evidence from shift-work physiology further supports the role of circadian disruption and vigilance impairment in increasing accident risk. Psychomotor vigilance testing in night-shift workers demonstrates marked slowing of reaction times and increased lapses during nocturnal duty periods [30]. In parallel, cortisol-rhythm misalignment documented in night-shift employees weakens the biological signals that normally promote wakefulness and cognitive performance, which may further impair attention and slow reaction times during safety-critical tasks [31]. These alterations mirror the cognitive vulnerabilities observed in OSA, suggesting that OSA-related sleep fragmentation combined with shift-related circadian strain may jointly magnify accident risk in rotating-shift environments.

From an international perspective, the association between OSA risk and occupational accident risk observed in this study is consistent with evidence reported across different countries and occupational settings. Increased rates of work-related injuries among workers with OSA have been documented in industrial and transportation sectors, particularly in shift-working populations [3]. Moreover, systematic reviews and meta-analyses have demonstrated a robust association between untreated OSA and occupational injury risk, with OSA conferring an approximately two-fold increase in work-related accidents across diverse work environments [32,33]. Although occupational contexts and regulatory frameworks differ between countries, the convergence of these findings underscores that the safety consequences of OSA extend beyond specific industries or regions. The present study contributes to this international literature by addressing a large yet under-studied group of rotating-shift textile workers, in whom sleep-related occupational safety risks remain poorly characterized.

From a practical perspective, the findings of this study have specific implications for the textile industry, where work is typically organized around continuous production processes, rotating shift schedules, and repetitive safety-sensitive tasks. In such settings, integrating brief OSA risk screening tools such as STOP-BANG into routine occupational health surveillance may facilitate early identification of workers at increased risk. In addition, shift-schedule design that limits prolonged sequences of night shifts and allows adequate recovery time between rotations may help reduce circadian and metabolic strain. Given the constraints of continuous production, workplace-level measures such as structured rest breaks, access to appropriate meal options during night shifts, and targeted education on sleep hygiene may further support healthier sleep–wake patterns. Finally, clearly defined referral pathways for diagnostic evaluation and management of suspected OSA within occupational health services are particularly relevant in the textile sector, where untreated sleep-disordered breathing may have important safety implications.

In addition, identifying workers at risk for OSA may represent a sensitive issue in occupational health practice. In some work environments, sleep disorders can be perceived as conditions that may affect fitness for work, which may raise concerns among workers about job security or stigmatization. Although there is no simple solution to this challenge, it is important to underline that the identification of OSA risk should aim to support worker health and safety rather than lead to exclusion from employment. Addressing sleep health within occupational surveillance therefore requires careful attention to confidentiality, ethical considerations, and the balance between workplace safety and workers' rights.

This study has several limitations. First, OSA risk was assessed using the STOP-BANG questionnaire rather than objective diagnostic tools such as polysomnography or polygraphy, which may have led to misclassification of OSA. Second, occupational accident history was obtained through self-report, creating the potential for recall bias or underreporting. In addition, no information was available on accident severity, such as injury type, medical visits, workers' compensation claims, or days absent from work, which should be considered when interpreting the findings. Third, all sleep-related variables; including sleep time and sleep latency were based on subjective questionnaires without objective confirmation through methods such as actigraphy. Fourth, although workers routinely performed six consecutive night shifts, accident data were not analyzed according to the specific night within the night-shift sequence. Therefore, the study could not determine whether cumulative fatigue across successive nights contributed to increased accident risk. In addition, the small number of female participants limited the ability to explore sex-specific differences, and the findings should be interpreted with caution regarding their applicability to more gender-diverse working populations. Despite these limitations, the study provides important insights into the association between OSA risk and occupational safety among rotating-shift workers.

5. Conclusions

This study highlights OSA risk as a significant and actionable contributor to occupational accidents in forward-rotating shift systems. Integrating sleep-health assessments, early identification of OSA, and fatigue-risk management into routine occupational safety frameworks may help reduce preventable injuries and improve workplace safety. Future research should incorporate objective sleep measurements and examine how accident risk changes across consecutive night shifts to guide more targeted and effective interventions.

Supplementary Materials

The additional data and information can be downloaded at: https://media.sciltp.com/articles/others/2601271607273970/WAH-25110165-Supplementary-Materials.pdf. Table S1: Univariable logistic regression analyses examining the associations between demographic, occupational, clinical, and sleep-related variables and occupational accident risk.

Author Contributions

R.C.U.: Data curation, field investigation, writing—original draft preparation; O.K.K.: Data curation, investigation, writing—original draft preparation; Z.N.T.: Conceptualization, methodology, formal analysis, interpretation of data, supervision, writing—review and editing; Ö.K.B.: Conceptualization, methodology, supervision, validation, writing—review and editing. All authors have read and agreed to the published version of the manuscript.

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Institutional Review Board Statement

The study was conducted according to the guidelines of the Declaration of Helsinki, and approved by the Institutional Ethics Committee of the Faculty of Medicine, Ege University (approval number: 24-2T/27 and date of approval: 8 February 2024).

Informed Consent Statement

Informed consent was obtained from all subjects involved in the study.

Data Availability Statement

The dataset generated and analyzed in this study contains sensitive personal and health-related information and cannot be made publicly available due to ethical and legal restrictions. Data may be obtained from the corresponding author upon reasonable request, and only with approval from the Ege University Medical Research Ethics Committee. All data will be retained and made accessible to qualified researchers for at least 10 years after publication, in accordance with institutional and journal policies.

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Conflicts of Interest

The authors declare no conflict of interest.

Use of AI and AI-Assisted Technologies

During the preparation of this work, the authors used an AI-assisted language tool (ChatGPT, OpenAI) to improve language clarity and readability. After using this tool/service, the authors reviewed and edited the content as needed and take full responsibility for the content of the published article.

References

1. American Academy of Sleep Medicine. *The International Classification of Sleep Disorders—Third Edition (ICSD-3)*; AASM: Darien, IL, USA, 2014.
2. Tregear, S.; Reston, J.T.; Schoelles, K.; et al. Obstructive sleep apnea and risk of motor vehicle crash: Systematic review and meta-analysis. *J. Clin. Sleep Med.* **2009**, *5*, 573–581.
3. Garbarino, S.; Guglielmi, O.; Sanna, A.; et al. Risk of occupational accidents in workers with obstructive sleep apnea: Systematic review and meta-analysis. *Sleep* **2016**, *39*, 1211–1218.
4. Harrington, J.M. Health effects of shift work and extended hours of work. *Occup. Environ. Med.* **2001**, *58*, 68–72.
5. International Labour Organization. *Guide to Developing Balanced Working-Time Arrangements*; ILO: Geneva, Switzerland, 2012.
6. Wagstaff, A.S.; Lie, J.A.S. Shift and night work and long working hours—A systematic review of safety implications. *Scand. J. Work Environ. Health* **2011**, *37*, 173–185.
7. Folkard, S.; Tucker, P. Shift work, safety and productivity. *Occup. Med.* **2003**, *53*, 95–101.
8. Yang, C.C.; Lee, K.W.; Watanabe, K.; et al. The association between shift work and possible obstructive sleep apnea: A systematic review and meta-analysis. *Int. Arch. Occup. Environ. Health* **2021**, *94*, 1763–1772. https://doi.org/10.1007/s00420-021-01675-1.
9. Malicki, M.; Karuga, F.F.; Szmyd, B.; et al. Obstructive Sleep Apnea, Circadian Clock Disruption, and Metabolic Consequences. *Metabolites* **2023**, *13*, 60.
10. International Labour Office. *Investigation of Occupational Accidents and Diseases: A Practical Guide for Labour Inspectors*; ILO: Geneva, Switzerland, 2014.
11. Chung, F.; Abdullah, H.R.; Liao, P. STOP-Bang questionnaire: A practical approach to screen for obstructive sleep apnea. *Chest* **2016**, *149*, 631–638.
12. Johns, M.W. A new method for measuring daytime sleepiness: The Epworth Sleepiness Scale. *Sleep* **1991**, *14*, 540–545.
13. İzci, B.; Ardıç, S.; Fırat, H.; et al. Reliability and validity studies of the Turkish version of the Epworth Sleepiness Scale. *Sleep Breath.* **2008**, *12*, 161–168.
14. Buysse, D.J.; Reynolds, C.F.; Monk, T.H.; et al. The Pittsburgh Sleep Quality Index. *Psychiatry Res.* **1989**, *28*, 193–213.
15. Ağargün, M.Y.; Kara, H.; Anlar, O. Pittsburgh Uyku Kalitesi İndeksi'nin geçerliği ve güvenirliği. *Türk Psikiyatr. Derg.* **1996**, *7*, 107–115.
16. Morin, C.M.; Belleville, G.; Bélanger, L.; et al. The Insomnia Severity Index: Psychometric indicators to detect insomnia cases and evaluate treatment response. *Sleep* **2011**, *34*, 601–608.
17. Boysan, M.; Güleç, M.; Beşiroğlu, L.; et al. Turkish version of the Insomnia Severity Index. *Anadolu Psikiyatr. Derg.* **2010**, *11*, 248–252.
18. Senaratna, C.V.; Perret, J.L.; Lodge, C.J.; et al. Prevalence of obstructive sleep apnea in the general population. *Sleep Med. Rev.* **2017**, *34*, 70–81.
19. Boersma, G.J.; Mijnster, T.; Vantyghem, P.; et al. Shift work is associated with extensively disordered sleep, especially when working nights. *Front. Psychiatry* **2023**, *14*, 1233640.
20. Reis, C.; Staats, R.; Pellegrino, P.; et al. The prevalence of excessive sleepiness is higher in shift workers than in patients with obstructive sleep apnea. *J. Sleep Res.* **2020**, *29*, e13073.
21. Sweetman, A.; Lack, L.; McEvoy, R.D.; et al. Bi-directional relationships between co-morbid insomnia and sleep apnea (COMISA). *Sleep Med. Rev.* **2021**, *60*, 101519.

22. Zhang, Y.; Ren, R.; Lei, F.; et al. Worldwide and regional prevalence rates of co-occurrence of insomnia and obstructive sleep apnea: Systematic review and meta-analysis. *Sleep Med. Rev.* **2019**, *45*, 1–17.
23. Ghahramani, F.; Ahmadi, M.; Alizadeh, H. Sleep Apnea and Occupational Accidents: A Systematic Review and Meta-Analysis. *J. Sleep Res.* **2018**, *27*, e12503.
24. Taşbakan, M.S.; Ekren, P.K.; Uysal, F.E.; et al. Evaluation of traffic accident risk in in-city bus drivers: The use of Berlin Questionnaire. *Turk. Thorac. J.* **2018**, *19*, 73–76.
25. Beebe, D.W. Neurobehavioral effects of obstructive sleep apnea: An overview and heuristic model. *Curr. Opin. Pulm. Med.* **2005**, *11*, 494–500.
26. Jackson, M.L.; Howard, M.E.; Barnes, M. Cognition and daytime functioning in sleep-related breathing disorders. *Prog. Brain Res.* **2011**, *190*, 53–68.
27. Garbarino, S.; Scoditti, E.; Lanteri, P.; et al. Obstructive sleep apnea with or without excessive daytime sleepiness: Clinical and experimental data-driven phenotyping. *Front. Neurol.* **2018**, *9*, 505.
28. Bianchi, M.T.; Williams, K.L.; McKinney, S.; et al. The subjective–objective mismatch in sleep perception in insomnia and sleep apnea. *J. Sleep Res.* **2013**, *22*, 557–568.
29. Morrone, E.; D'Artavilla Lupo, N.; Trentin, R.; et al. Microsleep as a marker of sleepiness in obstructive sleep apnea patients. *J. Sleep Res.* **2020**, *29*, e12882.
30. Behrens, T.; Burek, K.; Pallapies, D.; et al. Decreased psychomotor vigilance of female shift workers after working night shifts. *PLoS ONE* **2019**, *14*, e0219087.
31. Burek, K.; Rabstein, S.; Kantermann, T.; et al. Night work, chronotype and cortisol at awakening in female hospital employees. *Sci. Rep.* **2022**, *12*, 6525.
32. Uehli, K.; Mehta, A.J.; Miedinger, D.; et al. Sleep problems and work injuries: A systematic review and meta-analysis. *Sleep Med. Rev.* **2014**, *18*, 61–73. https://doi.org/10.1016/j.smrv.2013.01.004.
33. Chou, K.T.; Tsai, Y.L.; Yeh, W.Y.; et al. Risk of work-related injury in workers with obstructive sleep apnea: A systematic review and meta-analysis. *J. Sleep Res.* **2022**, *31*, e13446. https://doi.org/10.1111/jsr.13446.