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Shift Work as a Risk Factor for Poor Sleep Quality and Daytime Sleepiness in Khorasan Railway Personnel in Iran

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Abstract

Background: Shift work disrupts the sleep rhythm and leads to daily sleepiness and physical and mental complications.
Objectives: This study aimed to investigate the predictive role of shift work in poor sleep quality and daytime sleepiness in railway personnel.
Methods: This descriptive-analytical and cross-sectional study was conducted on the employees of the Khorasan railway in Iran in 2021, 450 individuals of whom were selected as a sample using the census sampling method. The data collection method was through a checklist containing demographic information and related factors (e.g., employment history) and through a physician to evaluate underlying diseases, body mass index (BMI), smoking and use of substances (past medical history), and completion of standard questionnaires, including the Pittsburgh Sleep Quality Index (PSQI), Karolinska Sleepiness Scale (KSS), and STOP-BANG questionnaire. The data were analyzed using the *t*-test and simultaneous multivariate regression analysis by SPSS software (version 24).
Results: Out of 450 employees, 144 (32%) and 306 (68%) subjects were day workers and shift workers, respectively. The average age of the participants was 40 ± 5.97 years. A significant difference was observed between the BMI with PSQI, KSS, and STOP-BANG scores (P = 0.001). Additionally, binary logistic regression analysis showed that shift work had a significant effect as a risk factor on both PSQI scores (CR = 1.25, 95% CI: 1.16-1.32, P = 0.001) and KSS scores (CR = 1.43, 95% CI: 1.29 - 1.59, P = 0.001).
Conclusions: Shift work could increase the amount of sleepiness during work in personnel as the main cause, along with other effective factors, such as personal and occupational characteristics.

Keywords: Daytime Sleepiness, Occupational Health, Shift Work Schedule, Sleep Disorders, Sleep Quality

1. Background

A significant percentage of the active population in a company works outside normal working hours (7:00 to 14:00) (1, 2). Shift work is especially important for healthcare and emergency services, hospitality, manufacturing, and transport (3). These shifts, particularly those at night, disrupt the natural circadian rhythm of the body's biological activities. This arrhythmia can be an essential factor in increasing the risk of various diseases, such as cardiovascular diseases and mental illnesses (3, 4). Currently, researchers have even studied the effect of circadian arrhythmias on the body's immune system and the possible increased risk of infection in humans (5). Circadian arrhythmias caused by night shifts cause fatigue, sleepiness, and lack of concentration during the day, affecting individuals' daily efficiency and leading to additional costs to society and exorbitant healthcare costs (6, 7).

Based on the literature review, various factors, such as demographic characteristics (8, 9), type of job (10, 11), and some health-related factors, such as body mass index (BMI) (12), blood pressure (13), and other medical problems (14), can be effective in the sleep quality and its indicators in shift workers. In a study conducted on 129 German industrial workers in 2022, Casjens et al. showed that shift workers had a median absolute social jet lag of more than 3 hours (15). Casjens et al. also showed that even this jet lag is significantly more severe for permanent night workers

(15).

Melan and Cascino aimed to investigate the effects of a modified shift work organization and traffic load on air traffic controllers' sleep and alertness and concluded that a shift work schedule has harmful consequences for the alertness and sleep quality of air traffic controllers (16). Park et al. showed that 79.8% of nurses in acute hospitals in South Korea have poor sleep quality (17). In addition, they showed that age and shift work could be predictive factors of nurse productivity. Moreover, a systematic review investigated the relationship between working the night shift and oxidative stress in different jobs, and the results showed that the significantly positive relationship between these two factors could be attributed to the increase in deoxyribonucleic acid damage and lipid peroxidation and decrease in antioxidant defense (18). The aforementioned factors can also lead to chronic diseases and poor life quality.

Work in railway transport is one of the most important groups in terms of shift work, necessary due to the role of personnel in the public transportation system, efficiency, alertness, concentration, and precision to maintain the health of passengers (19-21). Therefore, in these individuals, circadian rhythm disorders can lead to irreparable accidents for the general public and the risks mentioned for themselves (22, 23). Dorrian et al., in an online survey, investigated the relationship between multiple interrelated factors (i.e., train drivers' schedule, sleep, well-being, and fatigue) and the perceived influence of these factors on train driving performance and safety in Australia and New Zealand (24). Dorrian et al. found that schedule irregularity had the largest and most persistent negative effects on physical and mental health and outside work factors on driving performance (24).

Fan and Smith assessed fatigue and its causes as a critical factor in maintaining the health and safety of railway workers (25). The results of this study showed that long working hours, heavy workloads, night and morning shifts, and lack of sleep are the main causes of fatigue among railway personnel. Factors such as individual differences, individuals' job responsibilities, and an inappropriate work environment might also be at work (25). In Iran, a study examined general health, including physical symptoms, anxiety and depression symptoms, sleep disorders, and social efficiency, among day and night workers of the Tehran and Suburbs Metro Company (26). The results of this study showed that the average general health scores in all the aforementioned areas were higher in day workers than in night workers. However, to date, no study has investigated the effect of shift work on sleep quality and daily sleepiness in railway personnel based on health-related factors and the type of work they do. Therefore, the evidence shows that the country's public transportation systems, including railway transport and personnel, are directly at risk of shift work. Therefore, studying the sleep quality of railroad workers and the causes of sleep disorders and trying to find solutions to reduce risks and complications can greatly improve the health and safety of the general public.

2. Objectives

This study aimed to investigate the predictive role of shift work in poor sleep quality and daytime sleepiness in railway personnel.

3. Methods

3.1. Study Design and Ethical Considerations

This cross-sectional descriptive-analytical study was conducted on Khorasan railway personnel in Iran in 2021. The participants were fully informed about the research process and completed the informed consent form. This study was approved by the ethics code of IR.MUMS.MEDICAL.REC.1399.682 by the Ethics Committee of the Faculty of Medicine, Mashhad University of Medical Sciences, Mashhad, Iran.

3.2. Participants and Study Protocol

The statistical sample of this study was all Khorasan railway employees who were included in the study using the census sampling method. Through an official notification to the common channel of a virtual social network and a text message to all the employees of Khorasan railway, the announcement related to periodical occupational evaluation was issued. A total of 493 employees were referred to an occupational medicine clinic in Mashhad, and after checking the inclusion criteria, the information of 450 employees from this population was analyzed. The inclusion criteria were employment in Khorasan railway, not suffering from severe psychiatric diseases, and not using sleeping pills and any substances at least in the last 6 months.

The evaluation of all participants was regularly planned and carried out on Fridays (Friday as an official weekly holiday in Iran) in March and April 2021 from 9:00 a.m. to 1:00 p.m. During the evaluation process, the research objectives were explained to the participants, and informed consent was obtained before the start of data collection. Initially, a checklist containing demographic information and related factors, such as employment history, was completed for each participant. The BMI, underlying diseases, smoking, and use of substances (past medical history) were also investigated by a physician.

Then, each participant was asked to complete the Karolinska Sleepiness Scale (KSS) to check the sleepiness level, the Pittsburgh Sleep Quality Index (PSQI) to check sleep quality, and the STOP-BANG questionnaire to check obstructive sleep apnea (OSA). The main component in this study was shift work, defined as work outside the period of 7:00 a.m. to 2:00 p.m. Shift work was defined as fixed day work or rotating morning (7:00 a.m. to 7:00 p.m.) and night (7:00 p.m. to 7:00 a.m.) shifts. Then, the participants in this study were divided into two groups: day work and shift work.

3.3. Research Tools

3.3.1. Karolinska Sleepiness Scale

This scale was designed by Akerstedt and Gillberg in 1990 with nine options, which is graded from 1 (completely conscious) to 9 (trying to stay awake), and is valid for evaluating the level of sleepiness (27). Each subject gets a score from 1 to 9, with higher scores indicating a higher level of perceived sleepiness (27). A score of 7 is considered the cut-off point of this questionnaire, which indicates the need for interventions. This scale determines the subjective levels of sleepiness at a specific time during the day and has been widely used in studies related to sleep deprivation, driving, and shift work (28). The content validity ratio (CVR) and content validity index (CVI) for the Persian version of this questionnaire are reported as 0.86 and 0.81, respectively (29).

3.3.2. Pittsburgh Sleep Quality Index

This 7-item questionnaire estimates the quality of individuals' sleep based on an individual's personal opinion about the subjective sleep quality, sleep latency, sleep duration, sleep disturbances, use of sleep medication, daytime dysfunction, sleep efficiency, and total sleep quality (30, 31). The aforementioned items are given a score between 0 to 3 by the studied subjects; as a result, the overall scores of the subjects are between 0 to 21. Higher scores indicate poorer sleep quality (30). According to the designers of this questionnaire, scores higher than 5 indicate poor sleep quality (30). This questionnaire has been translated into Persian, and its reliability and validity have been evaluated in the Iranian population (32). The CVR and CVI for the Persian version of this questionnaire are reported as 0.93 and 0.8, respectively (33).

3.3.3. STOP-BANG Questionnaire

This questionnaire includes eight items regarding gender, history of frequent loud snoring in sleep, daytime sleepiness, breathing interruption during sleep, history of high blood pressure, age over 50 years, BMI above 35 kg/m^2, and neck circumference above 40 cm in yes-no form and screens the possibility of OSA (34). The scores of this questionnaire range from 0 to 8 points, and scores higher than 4 indicate a higher probability of OSA (34). This questionnaire has been translated into Persian. The CVR and CVI for the Persian version of this questionnaire are reported as 0.8 and 0.81, respectively (35).

3.4. Statistical Analysis

The collected data were analyzed by SPSS software (version 24). The assumption of normality of data was checked and confirmed by the Kolmogorov-Smirnov test ($P > 0.05$). Several hypotheses were measured using the independent *t*-test. The significance level was set at 0.05. Binary logistic regression analysis was performed using the "Enter" method to identify the effect of shift work on the variables of sleep quality and daytime sleepiness.

4. Results

The data of 450 employees of Khorasan railway were analyzed, 144 (32%) and 306 (68%) of whom were day workers and shift workers, respectively. The average age of the participants in the entire statistical sample was 40 years (42.04 and 39.11 years for day workers and shift workers, respectively). Table 1 shows the demographic and health-related data and their comparison (between the two groups of the day and shift work).

The comparison of PSQI, KSS, and STOP-BANG scores with the BMI factor was examined in the participants by dividing them into two groups (based on the BMI higher than and equal to 25 - below 25) and the *t*-test (Table 2). A significant difference was observed between the BMI with PSQI, KSS, and STOP-BANG scores ($P = 0.001$).

Based on Table 3, the comparison of PSQI scores between day and shift work groups showed a significant difference between the groups ($P = 0.01$). The average PSQI score in the entire statistical sample was equal to 3.99 (3.56 and 4.19 for day workers and shift workers, respectively), indicating a better sleep quality in the group of day workers ($P = 0.01$ and $P = 0.001$, respectively). In addition, the frequency of poor sleep quality, defined as a PSQI score of 5 or higher, was higher in the shift work population (31%) than in the day workers (29%).

The average KSS scores were 3.47, 4.04, and 4.32 for the day workers, total sample, and shift workers, respectively. All three mentioned scores are within the alert range, which indicates greater vigilance among the day work population. In addition, the frequency of severe sleepiness, defined as KSS scores of 7 or higher, was higher in shift work (5%) than in day work (1.3%). The comparison between KSS

Table 1. Comparison of Demographic and Health-related Data in Day and Shift Work Personnel [a]

Variables	Values	Day Work	Shift Work	P-Value
Age (y)	40 ± 5.97	42.04 ± 5.69	39.11 ± 5.86	0.056
Gender				
Male	450 (100)	144 (32)	306 (68)	0.009
Education				
Bachelor's and higher	148 (33)	44 (30.5)	104 (34)	0.003
Lower than bachelor's	302 (67)	100 (69.5)	202 (66)	0.005
Working experience (y)	11 ± 5.9	12.1 ± 6.32	10.09 ± 5.59	0.003
Body mass index (kg/m^2)				
Underweight (< 18.5)	7 (1.5)	0 (0)	7 (2)	0.001
Normal (> 18.5, < 25)	153 (34)	43 (30)	110 (36)	0.004
Overweight (> 25, < 30)	225 (50)	77 (53.5)	148 (48.5)	0.005
Obese (> 30)	65 (14.5)	24 (16.5)	41 (13.5)	0.008
Total	26.36 ± 3.55	24.26 ± 3.32	26.13 ± 4.32	0.001
Hypertension	14 (1.3)	3 (2)	11 (3.5)	0.005
Dyslipidemia	95 (21.1)	25 (17.3)	70 (22.8)	0.008
Diabetes	27 (6)	4 (2.7)	23 (7.5)	0.002
Smoking	5 (1.1)	1 (0.7)	4 (1.3)	0.004

[a] Values are expressed as mean ± standard deviation or No. (%).

Table 2. Mean, Standard Deviation, and Statistical Significance of Pittsburgh Sleep Quality Index, Karolinska Sleepiness Scale, and STOP-BANG Scores Based on Body Mass Index Scores

Scale	BMI > 25 kg/m^2	BMI < 25 kg/m^2	P-Value
Pittsburgh Sleep Quality Index	4.23 ± 2.12	3.79 ± 2.01	0.001
Karolinska Sleepiness Scale	4.12 ± 1.21	3.99 ± 1.04	0.001
STOP-BANG	2.01 ± 0.75	1.79 ± 0.88	0.001

Abbreviation: BMI, body mass index.

scores and shift work was evaluated by the *t*-test, and a significant difference was observed according to P = 0.001. The average STOP-BANG scores in the shift workers, total sample, and day workers were 1.76, 1.81, and 1.9, respectively, which showed low risk for OSA in all three groups (Table 3). Due to the no significance of STOP-BANG scores, this variable was not included in the binary logistic regression analysis.

The most important goal of this study was to determine the role of shift work as a possible predictive variable (a risk or protective factor) in PSQI and KSS scores. For this purpose, binary logistic regression analysis in Table 4 shows that shift work has a significant effect as a risk factor on both PSQI scores (CR = 1.25, 95% CI: 1.16 - 1.32, P = 0.001) and KSS scores (CR = 1.43, 95% CI: 1.29 - 1.59, P = 0.001).

5. Discussion

Due to the high occurrence rate of rail accidents and the resulting socioeconomic consequences in today's world, it is necessary to pay more attention to possible causes or effective factors. Studies have shown that human factors are among the most important factors affecting these accidents (36, 37). This issue becomes much more important considering the rights of each individual to have health and satisfaction in life. Therefore, conducting further studies in these fields can be effective in making policies related to the health of employees and then reducing the aforementioned negative consequences. In this regard, the analysis of the data of the present study showed that shift work could be considered a risk factor for sleep quality and daily sleepiness. In addition, the effect of shift work on the level of sleepiness was more than the total

Table 3. Comparison of Mean, Standard Deviation, and Number (%) of High Scores of Pittsburgh Sleep Quality Index, Karolinska Sleepiness Scale, and STOP-BANG in the Statistical Sample of Day and Shift Work Personnel

Scale and Group	Mean ± Standard Deviation	No. (%) of High Scores [a]	P-Value
Pittsburgh Sleep Quality Index			0.01
Day work	3.56 ± 1.64	42 (29)	
Shift work	4.19 ± 2.45	96 (31)	
Total	3.99 ± 2.24	138 (30)	
Karolinska Sleepiness Scale			0.001
Day work	3.47 ± 1.35	2 (1.3)	
Shift work	4.32 ± 1.17	15 (5)	
Total	4.04 ± 1.19	17 (3.7)	
STOP-BANG			0.06
Day work	1.9 ± 0.88	8 (0.05)	
Shift work	1.76 ± 0.85	14 (0.05)	
Total	1.81 ± 0.86	22 (0.05)	

[a] The No. (%) of participants who had scores above the cut-off points of each scale; High scores: PSQI score ≥ 5; KSS score ≥ 7; STOP-BANG score ≥ 4

Table 4. Binary Logistic Regression Analysis to Determine the Role of Shift Work in Pittsburgh Sleep Quality Index and Karolinska Sleepiness Scale Scores

Dependent Variable	B	S.E.	P-Value	Odds Ratio (95% CI)
Pittsburgh Sleep Quality Index	0.12	0.05	0.001	1.25 (1.16 - 1.32)
Karolinska Sleepiness Scale	0.17	0.07	0.001	1.43 (1.29 - 1.59)

sleep quality. Furthermore, employees who had a higher BMI had poorer sleep quality and more daytime sleepiness, and OSA problems.

Shift work railway workers are highly susceptible to fatigue from lack of sleep, which can prevent them from performing safety-critical functions (38). Disturbances in the 24-hour light-dark pattern incident on the retina appear to play a central role in exacerbating these problems, particularly regarding nocturnal light exposure and circadian rhythm disturbances (38, 39). Recent evidence has revealed that poor sleep quality can induce physiological and psychological stress responses (40). Gut microbes showed generational changes and disruptions of gut microbes in mice with circadian rhythm disturbances and individuals with jet lag (40). Therefore, one of the most important reasons explaining the effect of shift work on sleep quality and daily sleepiness might be the changes in circadian rhythms (41). Since circadian rhythms regulate basic biological processes, such as feeding (weight), body temperature, metabolic settings, hormone secretion, and the sleep-wake cycle, changes in shift work can affect sleep quality and daytime sleepiness (42, 43). In addition, these disturbed biological processes can, in turn, reinforce this faulty cycle and cause more negative effects on sleep quality.

Several studies have stated that the level of sleepiness of employees is directly related to the level of activity of individuals, shift work, type and level of activity, income, the psychological condition of individuals, and conflicts (44-46). Operations in railway services require precision, which often becomes more important due to the short reaction time (46). Therefore, working in railway services is challenging due to the amount of responsibility, mental preparation requirements, and stress levels imposed on the individual (47, 48). Railway employees, drivers, and traffic controllers should maintain their consciousness and immediately react to irregular events and important messages quickly and promptly. Improvement is required in the aftermath of hard work (49).

Studies have revealed that specific work conditions often disrupt individuals' physical and mental improvement processes (50), including sleep as the most critical process (49, 50). Harma et al. mentioned fatigue and sleepiness as common problems in railway transportation with occasional monotony and irregular work schedules (51). In the aforementioned study, 230 subjects, including 126 male train drivers and 104 railway traffic control experts, were randomly selected from the Finnish railway population. The information related to sleep and their level of sleepiness were examined over 21 days through the Karolinska questionnaire and the sleep information record notebook. The aforementioned study reported severe sleepiness in 49% and 50% of the train drivers and railway traffic control staff during night shifts within the study period, respectively. However, the incidence of severe sleepiness in train drivers and railway traffic control workers in morning shifts was lower than in night shifts and equivalent to 15% and 20%, respectively. The aforementioned study demonstrated that the risk of severe sleepiness in night shifts was 4 to 16 times higher than in day shifts, indicating more sleepiness in shift workers than in day workers, similar to the present study (51).

Fan and Smith reviewed 31 studies on fatigue in railway workers (52). In the aforementioned study, fatigue was mentioned as a severe problem in the railway industry, which can affect the health and safety of railway employees. The aforementioned study showed that the leading causes of fatigue in railway personnel are lengthy working hours, high workload, night and early morning shifts, and lack of sleep. In addition, factors such as individual differences, individuals' positions, and poor work environments can also be effective. The results of the present study also showed the correlation between shift work with fatigue and sleepiness (52). Pylkkonen et al. evaluated the relationship between working hours and shift work with sleep quality and sleepiness among truck drivers (53). The aforementioned study reported sleepiness as a common phenomenon among professional drivers who work during irregular hours. In the aforementioned study, 54 truck drivers were examined for 2 weeks, and the Karolinska questionnaire was used to examine the level of sleepiness. The results showed that the highest prevalence of severe sleepiness, defined as KSS scores of 7 or higher, occurs on the night shift (37.8%) and the lowest on the morning shift (10%). The ratio of the number of shifts in which the drivers used measures to combat sleepiness at least once out of the prescribed rest times was about 22% higher in night shifts than in nonnight shifts. Therefore, more sleepiness was observed during shift work at unusual hours, similar to the present study (53).

Lee et al. found sleepiness while driving as a significant factor in traffic accident deaths (54). The amount of sleepiness while driving was measured in 332 bus drivers using the Karolinska questionnaire, which was investigated in two groups of drivers with two daily shifts and drivers with alternating day shifts. The results showed that the incidence of severe sleepiness in drivers with alternating day shifts is much higher than in the group of drivers with two daily shifts in the evening (after lunchtime until the end of the shift) (54). Irregular work schedules in the group of drivers with alternating day shifts can be one of the reasons for creating this significant difference from the group of drivers with two daily shifts, confirming the result of the present study regarding the incidence of sleepiness in shift workers. Cotrim et al. investigated the effect of work and personal factors, such as shift work, on sleepiness in railway control workers and found a high incidence of sleepiness in night shifts among railway control workers (55).

Another result of the present study was a significant difference in sleep quality, sleepiness, and OSA based on the BMI of the personnel. Numerous previous studies have also shown that the relationship between changes in metabolic processes and weight gain is bilateral, and this relationship cannot be considered cause and effect (56-58). In a systematic review that examined 31 cross-sectional and 5 cohort studies, the findings indicated that sleep problems could be strongly related to current and future weight gain (59). From an explanatory point of view, it can be interesting to note that the increase in food consumption in shift workers might lead to an increase in fatigue and calorie intake and ultimately end up in a decrease in physical activity (60). From the biological point of view, it can be mentioned that important proteins in regulating circadian rhythms, such as CLOCK and BMAL-1, are also present in fat tissues and the suprachiasmatic nucleus (61, 62). On the other hand, animal and human studies have shown that weight gain can affect the production of pro-inflammatory cytokines, which can create a common point with sleep problems (63). Therefore, sleep problems can activate the pathway by which the hypothalamus-pituitary-adrenal axis affects metabolic changes, such as oxidative stress, pro-inflammatory cytokines, and insulin resistance, and probably ultimately causes weight gain (58).

In line with the findings of the present study, Hulsegge et al. conducted a cross-sectional study on 3188 shift workers and 6395 non-shift workers whose health status was examined within 2013 to 2018 in periodical occupational health (64). Hulsegge et al.'s findings indicated that shift workers were at greater risk of obesity, diabetes, lower physical activity levels, less fruit and vegetable consumption, more smoking, and poor sleep quality (64). Jaradat et al. investigated sleep quality, health risks, and chronic diseases in postgraduate resident physicians who work on rotating shifts at a large tertiary healthcare center, and the findings showed that out of a total of 201 participating resident physicians in the study, 41.3% were overweight (65). Additionally, almost 90% of the participants had poor sleep quality, and more than a third of them were smokers (65). As mentioned earlier, such studies can be effective in planning interventions to improve the health, life, and career quality of shift workers.

This study had several limitations. Firstly, the findings of this study cannot be generalized to female personnel because only male subjects were evaluated. Secondly, the characteristics of sleep quality were examined subjectively; it is recommended to use objective methods, such as polysomnography and functional magnetic resonance imaging, for further exploration in future studies. The third limitation was the lack of appropriate advice and further monitoring of personnel to improve their sleep quality indicators. Nevertheless, it is possible that the results of this study can help use interventions more effectively or develop more appropriate interventions.

5.1. Conclusions

Shift work in unusual working hours increases the amount of sleepiness during work. Factors, such as individual characteristics, can also be effective in intensifying and mitigating sleepiness. This issue plays a more prominent role in occupational groups, such as railway personnel, whose accuracy and consciousness during work are necessary to maintain the safety and health of the general public.

5.2. Statement

Given that jobs, such as working in railways, are forced to operate around the clock for the comfort of the general public, shift work in hours other than normal working hours is inevitable. On the other hand, such shifts increase the risk of various diseases, sleepiness during work, and related risks. Therefore, detailed planning is required for the shift work of railway employees and individual characteristics and positions of people in these programs to reduce the risks caused by such shift work.

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Footnotes

Authors' Contribution: The article's first and sixth authors were responsible for implementing the study, selecting the sample based on the inclusion and exclusion criteria, obtaining written informed consent from the participants, collecting data, conducting the research, and writing the abstract and introduction. The second author was responsible for supervising the implementation, analysis, and statistical interpretation of research findings, discussion and conclusions, writing, and revising the article. The third, fourth, and fifth authors were responsible for supervising the implementation, conceptualization, and final editing of the manuscript. All the authors read and approved the final manuscript.

Conflict of Interests: The authors declare that they have no conflict of interests.

Data Reproducibility: The dataset presented in the study is available on request from the corresponding author during submission or after its publication. The data are not publicly available since they are presented in detail in the article.

Ethical Approval: This study was approved by the ethics code of IR.MUMS.MEDICAL.REC.1399.682 by the Ethics Committee of the Faculty of Medicine, Mashhad University of Medical Sciences.

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References

1. Messenger J. *Working time and the future of work*. **6**. Geneva, Switzerland: International Labour Organization; 2018.
2. Genin É. Proposal for a Theoretical Framework for the Analysis of Time Porosity. *Int J Comp Labour Law Ind Relat*. 2016;**32**(Issue 3):280–300. https://doi.org/10.54648/ijcl2016015.
3. Boivin DB, Boudreau P, Kosmadopoulos A. Disturbance of the Circadian System in Shift Work and Its Health Impact. *J Biol Rhythms*. 2022;**37**(1):3–28. [PubMed ID: 34969316]. [PubMed Central ID: PMC8832572]. https://doi.org/10.1177/07487304211064218.
4. Zhao Y, Lu X, Wan F, Gao L, Lin N, He J, et al. Disruption of Circadian Rhythms by Shift Work Exacerbates Reperfusion Injury in Myocardial Infarction. *J Am Coll Cardiol*. 2022;**79**(21):2097–115. [PubMed ID: 35618347]. [PubMed Central ID: PMC8972444]. https://doi.org/10.1016/j.jacc.2022.03.370.
5. Rijo-Ferreira F, Takahashi JS. Circadian rhythms in infectious diseases and symbiosis. *Semin Cell Dev Biol*. 2022;**126**:37–44. [PubMed ID: 34625370]. [PubMed Central ID: PMC9183220]. https://doi.org/10.1016/j.semcdb.2021.09.004.
6. Ganesan S, Magee M, Stone JE, Mulhall MD, Collins A, Howard ME, et al. The Impact of Shift Work on Sleep, Alertness and Performance in Healthcare Workers. *Sci Rep*. 2019;**9**(1):4635. [PubMed ID: 30874565]. [PubMed Central ID: PMC6420632]. https://doi.org/10.1038/s41598-019-40914-x.
7. Lallukka T, Sivertsen B, Kronholm E, Bin YS, Overland S, Glozier N. Association of sleep duration and sleep quality with the physical, social, and emotional functioning among Australian adults. *Sleep Health*. 2018;**4**(2):194–200. [PubMed ID: 29555134]. https://doi.org/10.1016/j.sleh.2017.11.006.
8. Brito RS, Dias C, Afonso Filho A, Salles C. Prevalence of insomnia in shift workers: a systematic review. *Sleep Sci*. 2021;**14**(1):47–54. [PubMed ID: 34104337]. [PubMed Central ID: PMC8157778]. https://doi.org/10.5935/1984-0063.20190150.
9. Wickwire EM, Geiger-Brown J, Scharf SM, Drake CL. Shift Work and Shift Work Sleep Disorder: Clinical and Organizational Perspectives. *Chest*. 2017;**151**(5):1156–72. [PubMed ID: 28012806]. [PubMed Central ID: PMC6859247]. https://doi.org/10.1016/j.chest.2016.12.007.
10. Garbarino S, Guglielmi O, Puntoni M, Bragazzi NL, Magnavita N. Sleep Quality among Police Officers: Implications and Insights from a Systematic Review and Meta-Analysis of the Literature. *Int J Environ Res Public Health*. 2019;**16**(5). [PubMed ID: 30862044]. [PubMed Central ID: PMC6427768]. https://doi.org/10.3390/ijerph16050885.

11. Kang J, Noh W, Lee Y. Sleep quality among shift-work nurses: A systematic review and meta-analysis. *Appl Nurs Res*. 2020;**52**:151227. [PubMed ID: 31902652]. https://doi.org/10.1016/j.apnr.2019.151227.
12. Crowther ME, Ferguson SA, Vincent GE, Reynolds AC. Non-Pharmacological Interventions to Improve Chronic Disease Risk Factors and Sleep in Shift Workers: A Systematic Review and Meta-Analysis. *Clocks Sleep*. 2021;**3**(1):132–78. [PubMed ID: 33525534]. [PubMed Central ID: PMC7930959]. https://doi.org/10.3390/clockssleep3010009.
13. Gamboa Madeira S, Fernandes C, Paiva T, Santos Moreira C, Caldeira D. The Impact of Different Types of Shift Work on Blood Pressure and Hypertension: A Systematic Review and Meta-Analysis. *Int J Environ Res Public Health*. 2021;**18**(13). [PubMed ID: 34201492]. [PubMed Central ID: PMC8269039]. https://doi.org/10.3390/ijerph18136738.
14. Kervezee L, Kosmadopoulos A, Boivin DB. Metabolic and cardiovascular consequences of shift work: The role of circadian disruption and sleep disturbances. *Eur J Neurosci*. 2020;**51**(1):396–412. [PubMed ID: 30357975]. https://doi.org/10.1111/ejn.14216.
15. Casjens S, Brenscheidt F, Tisch A, Beermann B, Bruning T, Behrens T, et al. Social jetlag and sleep debts are altered in different rosters of night shift work. *PLoS One*. 2022;**17**(1). e0262049. [PubMed ID: 34995309]. [PubMed Central ID: PMC8740972]. https://doi.org/10.1371/journal.pone.0262049.
16. Melan C, Cascino N. Effects of a modified shift work organization and traffic load on air traffic controllers' sleep and alertness during work and non-work activities. *Appl Ergon*. 2022;**98**:103596. [PubMed ID: 34628043]. https://doi.org/10.1016/j.apergo.2021.103596.
17. Park E, Lee HY, Park CS. Association between sleep quality and nurse productivity among Korean clinical nurses. *J Nurs Manag*. 2018;**26**(8):1051–8. [PubMed ID: 29855101]. https://doi.org/10.1111/jonm.12634.
18. Gibson M. A systematic review of the relationship between night shift work and oxidative stress. *Chronobiol Int*. 2022;**39**(2):285–98. [PubMed ID: 34647825]. https://doi.org/10.1080/07420528.2021.1989446.
19. Gartner J, Rosa RR, Roach G, Kubo T, Takahashi M. Working Time Society consensus statements: Regulatory approaches to reduce risks associated with shift work-a global comparison. *Ind Health*. 2019;**57**(2):245–63. [PubMed ID: 30700673]. [PubMed Central ID: PMC6449633]. https://doi.org/10.2486/indhealth.SW-7.
20. Fan J, Smith AP. Effects of Occupational Fatigue on Cognitive Performance of Staff From a Train Operating Company: A Field Study. *Front Psychol*. 2020;**11**:558520. [PubMed ID: 33041922]. [PubMed Central ID: PMC7517727]. https://doi.org/10.3389/fpsyg.2020.558520.
21. Tsao L, Chang J, Ma L. Fatigue of Chinese railway employees and its influential factors: Structural equation modelling. *Appl Ergon*. 2017;**62**:131–41. [PubMed ID: 28411723]. https://doi.org/10.1016/j.apergo.2017.02.021.
22. Rudin-Brown CM, Harris S, Rosberg A. How shift scheduling practices contribute to fatigue amongst freight rail operating employees: Findings from Canadian accident investigations. *Accid Anal Prev*. 2019;**126**:64–9. [PubMed ID: 29397875]. https://doi.org/10.1016/j.aap.2018.01.027.
23. Rudin-Brown CM, Rosberg A. Applying principles of fatigue science to accident investigation: Transportation Safety Board of Canada (TSB) fatigue investigation methodology. *Chronobiol Int*. 2021;**38**(2):296–300. [PubMed ID: 33441021]. https://doi.org/10.1080/07420528.2020.1863976.
24. Dorrian J, Chapman J, Bowditch L, Balfe N, Naweed A. A survey of train driver schedules, sleep, wellbeing, and driving performance in Australia and New Zealand. *Sci Rep*. 2022;**12**(1):3956. [PubMed ID: 35273197]. [PubMed Central ID: PMC8913649]. https://doi.org/10.1038/s41598-022-07627-0.
25. Fan J, Smith AP. The Impact of Workload and Fatigue on Performance. *Human Mental Workload: Models and Applications*. Dublin, Ireland. 2017. p. 90–105.
26. Rafiemanesh H, Mazloumi A, Fazli R, Heravizadeh O, Pourhossein M, Maleck-khani H, et al. [The Study and Comparison of General Health Status in Shift and Day Workers of Tehran Subway Operation Company: A Multivariate Analysis]. *Int J Occup Environ Health*. 2016;**2**(2):125–34. Persian.
27. Kaida K, Takahashi M, Akerstedt T, Nakata A, Otsuka Y, Haratani T, et al. Validation of the Karolinska sleepiness scale against performance and EEG variables. *Clin Neurophysiol*. 2006;**117**(7):1574–81. [PubMed ID: 16679057]. https://doi.org/10.1016/j.clinph.2006.03.011.
28. Miley AA, Kecklund G, Akerstedt T. Comparing two versions of the Karolinska Sleepiness Scale (KSS). *Sleep Biol Rhythms*. 2016;**14**(3):257–60. [PubMed ID: 28781579]. [PubMed Central ID: PMC5511283]. https://doi.org/10.1007/s41105-016-0048-8.
29. Zare R, Choobineh A, Keshavarzi S, Moghateli S. Investigation of the Relationship of Sleep Quality, Sleepiness and Sickness Absence. *Journal of Ergonomics*. 2016;**4**(2):1–7. https://doi.org/10.21859/joe-040230.
30. Aloba OO, Adewuya AO, Ola BA, Mapayi BM. Validity of the Pittsburgh Sleep Quality Index (PSQI) among Nigerian university students. *Sleep Med*. 2007;**8**(3):266–70. [PubMed ID: 17368977]. https://doi.org/10.1016/j.sleep.2006.08.003.
31. Bavafa A, Foroughi AA, Khaledi-Paveh B, abbas Taheri A, Fehrest F, Amiri S. The comparison of effects of state and trait anxiety on the components of sleep quality. *J Sleep Sci*. 2018;**3**(3-4):95–101.
32. Afkham Ebrahimi A, Bandi G, Salehi M, Tafti K, Vakili Y, Farsi A. [Sleep parameters and the factors affecting the quality of sleep in patients attending selected clinics of Rasoul-e-Akram hospital]. *Razi Journal of Medical Sciences*. 2008;**15**:31–8. Persian.
33. Bavafa A, Fadaei M, Anbarani B, Bameshghi M, Shekarian-Yazd F, Jaberghaderi N, et al. The Association between Emotional Intelligence and Sleep Quality Components in University Students. *J Sleep Sci*. 2019;**4**(1-2):37–43.
34. Luo J, Huang R, Zhong X, Xiao Y, Zhou J. STOP-Bang questionnaire is superior to Epworth sleepiness scales, Berlin questionnaire, and STOP questionnaire in screening obstructive sleep apnea hypopnea syndrome patients. *Chin Med J (Engl)*. 2014;**127**(17):3065–70. [PubMed ID: 25189946].
35. Sadeghniiat-Haghighi K, Montazeri A, Khajeh-Mehrizi A, Ghajarzadeh M, Alemohammad ZB, Aminian O, et al. The STOP-BANG questionnaire: reliability and validity of the Persian version in sleep clinic population. *Qual Life Res*. 2015;**24**(8):2025–30. [PubMed ID: 25613199]. https://doi.org/10.1007/s11136-015-0923-9.
36. Fan C, Huang S, Lin S, Xu D, Peng Y, Yi S. Types, Risk Factors, Consequences, and Detection Methods of Train Driver Fatigue and Distraction. *Comput Intell Neurosci*. 2022;**2022**:8328077. [PubMed ID: 35371223]. [PubMed Central ID: PMC8970922]. https://doi.org/10.1155/2022/8328077.
37. Li C, Tang T, Chatzimichailidou MM, Jun GT, Waterson P. A hybrid human and organisational analysis method for railway accidents based on STAMP-HFACS and human information processing. *Appl Ergon*. 2019;**79**:122–42. [PubMed ID: 30718024]. https://doi.org/10.1016/j.apergo.2018.12.011.
38. Sahin L, Figueiro MG. A 24-hour lighting scheme to promote alertness and circadian entrainment in railroad dispatchers on rotating shifts: A field study. *Light Res Technol*. 2021;**54**(5):441–57. https://doi.org/10.1177/14771535211040985.
39. Figueiro MG, Goo YH, Hogan R, Plitnick B, Lee JK, Jahangir K, et al. Light-Dark Patterns Mirroring Shift Work Accelerate Atherosclerosis and Promote Vulnerable Lesion Phenotypes. *J Am Heart Assoc*. 2021;**10**(2). e018151. [PubMed ID: 33401929]. [PubMed Central ID: PMC7955296]. https://doi.org/10.1161/JAHA.120.018151.
40. Sheta SS, Abbas RA, Abd El Wehab D. Metabolic Syndrome Predictors among Shift Workers of Zagazig Central Railway Station: A Case-Control Study. *Egypt J Hosp Med*. 2022;**87**(1):1553–60. https://doi.org/10.21608/ejhm.2022.226946.
41. Kazemi R, Haidarimoghadam R, Motamedzadeh M, Golmohamadi R, Soltanian A, Zoghipaydar MR. Effects of Shift Work

on Cognitive Performance, Sleep Quality, and Sleepiness among Petrochemical Control Room Operators. *J Circadian Rhythms*. 2016;**14**:1. [PubMed ID: 27103934]. [PubMed Central ID: PMC4834749]. https://doi.org/10.5334/jcr.134.

42. Fatima N, Sonkar GK, Singh S. Circadian mechanism disruption is associated with dysregulation of inflammatory and immune responses: a systematic review. *Beni-Suef Univ J Basic Appl Sci*. 2022;**11**(1). https://doi.org/10.1186/s43088-022-00290-4.
43. Wong SD, Wright KJ, Spencer RL, Vetter C, Hicks LM, Jenni OG, et al. Development of the circadian system in early life: maternal and environmental factors. *J Physiol Anthropol*. 2022;**41**(1):22. [PubMed ID: 35578354]. [PubMed Central ID: PMC9109407]. https://doi.org/10.1186/s40101-022-00294-0.
44. Skinner N, Dorrian J. A work-life perspective on sleep and fatigue–looking beyond shift workers. *Ind Health*. 2015;**53**(5):417–26. [PubMed ID: 26027709]. [PubMed Central ID: PMC4591134]. https://doi.org/10.2486/indhealth.2015-0009.
45. Litwiller B, Snyder LA, Taylor WD, Steele LM. The relationship between sleep and work: A meta-analysis. *J Appl Psychol*. 2017;**102**(4):682–99. [PubMed ID: 27893255]. https://doi.org/10.1037/apl0000169.
46. Elfering A, Grebner S, Haller M. Railway-controller-perceived mental work load, cognitive failure and risky commuting. *Ergonomics*. 2012;**55**(12):1463–75. [PubMed ID: 23002721]. https://doi.org/10.1080/00140139.2012.718802.
47. Makino T, Sakai H, Kozuka C, Yamazaki Y, Yamamoto M, Minoshima K. Overview of fatigue damage evaluation rule for railway axles in Japan and fatigue property of railway axle made of medium carbon steel. *Int J Fatigue*. 2020;**132**. https://doi.org/10.1016/j.ijfatigue.2019.105361.
48. Wu SC, Xu ZW, Kang GZ, He WF. Probabilistic fatigue assessment for high-speed railway axles due to foreign object damages. *Int J Fatigue*. 2018;**117**:90–100. https://doi.org/10.1016/j.ijfatigue.2018.08.011.
49. Grebner S, Elfering A, Semmer NK. The success resource model of job stress. In: Perrewé PL, Ganster DC, editors. *New developments in theoretical and conceptual approaches to job stress*. Bingley, England: Emerald Publishing Limited; 2010. https://doi.org/10.1037/e572992012-189.
50. Sonnentag S, Casper A, Pinck AS. Job Stress and Sleep. In: Barling J, Barnes CM, Carleton EL, Wagner DT, editors. *Work and sleep: Research insights for the workplace*. Oxford, England: Oxford University Press; 2016. p. 77–100. https://doi.org/10.1093/acprof:oso/9780190217662.003.0005.
51. Harma M, Sallinen M, Ranta R, Mutanen P, Muller K. The effect of an irregular shift system on sleepiness at work in train drivers and railway traffic controllers. *J Sleep Res*. 2002;**11**(2):141–51. [PubMed ID: 12028479]. https://doi.org/10.1046/j.1365-2869.2002.00294.x.
52. Fan J, Smith AP. A Preliminary Review of Fatigue Among Rail Staff. *Front Psychol*. 2018;**9**:634. [PubMed ID: 29867630]. [PubMed Central ID: PMC5949530]. https://doi.org/10.3389/fpsyg.2018.00634.
53. Pylkkonen M, Sihvola M, Hyvarinen HK, Puttonen S, Hublin C, Sallinen M. Sleepiness, sleep, and use of sleepiness countermeasures in shift-working long-haul truck drivers. *Accid Anal Prev*. 2015;**80**:201–10. [PubMed ID: 25957933]. https://doi.org/10.1016/j.aap.2015.03.031.
54. Lee S, Kim HR, Byun J, Jang T. Sleepiness while driving and shift-work patterns among Korean bus drivers. *Ann Occup Environ Med*. 2017;**29**:48. [PubMed ID: 29043087]. [PubMed Central ID: PMC5632830]. https://doi.org/10.1186/s40557-017-0203-y.
55. Cotrim T, Carvalhais J, Neto C, Teles J, Noriega P, Rebelo F. Determinants of sleepiness at work among railway control workers. *Appl Ergon*. 2017;**58**:293–300. [PubMed ID: 27633225]. https://doi.org/10.1016/j.apergo.2016.07.006.
56. Hollstein T, Piaggi P. Metabolic Factors Determining the Susceptibility to Weight Gain: Current Evidence. *Curr Obes Rep*. 2020;**9**(2):121–35. [PubMed ID: 32248352]. [PubMed Central ID: PMC7263968]. https://doi.org/10.1007/s13679-020-00371-4.
57. Piaggi P. Metabolic Determinants of Weight Gain in Humans. *Obesity (Silver Spring)*. 2019;**27**(5):691–9. [PubMed ID: 31012296]. [PubMed Central ID: PMC6481299]. https://doi.org/10.1002/oby.22456.
58. Muscogiuri G, Barrea L, Annunziata G, Di Somma C, Laudisio D, Colao A, et al. Obesity and sleep disturbance: the chicken or the egg? *Crit Rev Food Sci Nutr*. 2019;**59**(13):2158–65. [PubMed ID: 30335476]. https://doi.org/10.1080/10408398.2018.1506979.
59. Patel SR, Hu FB. Short sleep duration and weight gain: a systematic review. *Obesity (Silver Spring)*. 2008;**16**(3):643–53. [PubMed ID: 18239586]. [PubMed Central ID: PMC2723045]. https://doi.org/10.1038/oby.2007.118.
60. Beccuti G, Pannain S. Sleep and obesity. *Curr Opin Clin Nutr Metab Care*. 2011;**14**(4):402–12. [PubMed ID: 21659802]. [PubMed Central ID: PMC3632337]. https://doi.org/10.1097/MCO.0b013e3283479109.
61. Herrero L, Valcarcel L, da Silva CA, Albert N, Diez-Noguera A, Cambras T, et al. Altered circadian rhythm and metabolic gene profile in rats subjected to advanced light phase shifts. *PLoS One*. 2015;**10**(4). e0122570. [PubMed ID: 25837425]. [PubMed Central ID: PMC4383616]. https://doi.org/10.1371/journal.pone.0122570.
62. Ribas-Latre A, Eckel-Mahan K. Nutrients and the Circadian Clock: A Partnership Controlling Adipose Tissue Function and Health. *Nutrients*. 2022;**14**(10). [PubMed ID: 35631227]. [PubMed Central ID: PMC9147080]. https://doi.org/10.3390/nu14102084.
63. Liang JQ, Liang L, Jiang JJ, Liang L, Zhang HY. A retrospective cohort study of the effect of weight loss on chronic inflammation and sleep quality. *Int J Clin Exp Med*. 2022;**15**(6):199–203.
64. Hulsegge G, Proper KI, Loef B, Paagman H, Anema JR, van Mechelen W. The mediating role of lifestyle in the relationship between shift work, obesity and diabetes. *Int Arch Occup Environ Health*. 2021;**94**(6):1287–95. [PubMed ID: 33704584]. [PubMed Central ID: PMC8292292]. https://doi.org/10.1007/s00420-021-01662-6.
65. Jaradat R, Lahlouh A, Mustafa M. Sleep quality and health related problems of shift work among resident physicians: a cross-sectional study. *Sleep Med*. 2020;**66**:201–6. [PubMed ID: 31978863]. https://doi.org/10.1016/j.sleep.2019.11.1258.