Economic: Journal Economic and Business
Vol. 4, No. 2, April 2025, pp. 133~140

The Impact of Night Shift, Work-Life Balance, and Ergonomic Factors on Occupational Accident Risk with Compliance to Safety Protocols

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ABSTRAK

Penelitian ini bertujuan untuk menganalisis dampak shift malam, work-life balance, dan faktor ergonomi terhadap risiko kecelakaan kerja dengan kepatuhan terhadap protokol keselamatan sebagai variabel mediasi. Penelitian dilakukan terhadap 154 responden yang bekerja di sektor dengan risiko kerja tinggi. Metode analisis yang digunakan adalah Partial Least Squares Structural Equation Modeling (PLS-SEM). Hasil penelitian menunjukkan bahwa shift malam berpengaruh signifikan dan positif terhadap risiko kecelakaan kerja. Sementara itu, work-life balance dan faktor ergonomi berpengaruh signifikan terhadap peningkatan kepatuhan terhadap protokol keselamatan. Namun, variabel kepatuhan terhadap protokol keselamatan tidak berpengaruh signifikan terhadap risiko kecelakaan kerja, sehingga tidak dapat memediasi hubungan antar variabel dalam model ini. Temuan ini menegaskan pentingnya pengelolaan sistem shift malam secara lebih manusiawi serta penguatan aspek ergonomi dan keseimbangan hidup-kerja dalam menciptakan lingkungan kerja yang aman. Implikasi praktis dari penelitian ini mengarah pada perlunya intervensi manajerial dan kebijakan keselamatan kerja yang holistik. Penelitian selanjutnya disarankan untuk mempertimbangkan variabel tambahan seperti stres kerja atau budaya keselamatan, serta menggunakan pendekatan campuran untuk memperoleh pemahaman yang lebih komprehensif.

Keyword: Shift Malam; Keseimbangan Kerja dan Kehidupan; Faktor Ergonomik; Kecelakaan Kerja; Protokol Keselamatan

ABSTRACT

This study aims to analyze the impact of night shifts, work-life balance, and ergonomic factors on the risk of workplace accidents, with compliance to safety protocols as a mediating variable. The research was conducted on 154 respondents working in high-risk sectors. Data analysis was carried out using Partial Least Squares Structural Equation Modeling (PLS-SEM) with the SmartPLS 4 software. The results show that night shifts have a significant and positive effect on the risk of workplace accidents. Meanwhile, work-life balance and ergonomic factors significantly influence compliance with safety protocols. However, compliance with safety protocols does not significantly affect the risk of accidents, and thus does not mediate the relationships between the other variables in the proposed model. These findings highlight the importance of better-managed night shift systems and the reinforcement of ergonomic conditions and work-life balance in ensuring a safe working environment. The practical implications call for managerial interventions and holistic occupational safety policies. Future studies are recommended to include additional variables such as job stress or safety culture, and to consider mixed-method approaches for a more comprehensive understanding.

Keyword: Night Shift; Work-Life Balance; Ergonomic Factors; Work Accidents; Safety Protocols

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1. INTRODUCTION

Shift work, particularly night shifts, has become a common practice in many industries in order to meet the demands of 24-hour operations. Despite its benefits in terms of production and service continuity,

night shift work is consistently associated with an increased risk of occupational accidents. Numerous studies have shown that working at night can disrupt the body's natural circadian rhythms, impacting on sleep quality, fatigue levels, and impairment of workers' cognitive and motor functions (Malik et al., 2024; Możdżyńska et al., 2023; Zahid et al., 2022). As a result, workers become more vulnerable to work errors and injuries, both at work and on their way home.

This disruption to biological rhythms is exacerbated by the lack of adequate rest periods, unergonomic shift schedules, and night work environments that are often poorly lit and lack supervision. Empirical evidence from various countries shows that night shift workers are more likely to experience extreme fatigue, fall asleep on duty and have near-fatal accidents (Westwell et al., 2021; Vedaa et al., 2019). Research in the healthcare and heavy industry sectors also reveals that injuries are more common after a series of night shifts or when the return time between shifts is too short (Härmä et al., 2020; Nielsen et al., 2018). Sleep-wake disorders such as Shift Work Disorder (SWD) have also been identified as a major risk factor for occupational safety (Sachdeva & Goldstein, 2020).

Furthermore, organisational factors such as shift design, length of work duration, and lack of fatigue management training increase the risk. Studies from North Sea Oil Installations and hospitals show that injury severity is higher among night shift workers than day shift workers (Salminen, 2016; Horwitz & McCall, 2004). Therefore, systemic and evidence-based interventions are urgently needed. Some recommended strategies include the design of adaptive work schedules, sleep hygiene education, and the use of technology to monitor fatigue levels in real-time (Garde et al., 2020; Malik et al., 2024).

Based on this background, this study aims to further examine the relationship between night shift work, work-life balance, and ergonomic factors on occupational accident risk, with compliance with safety protocols as a mediating variable. Using a PLS-SEM-based quantitative approach, this study is expected to provide scientific and practical contributions to efforts to improve work safety, especially in the work sector that applies the night shift system.

2. LITERATURE REVIEW

Night shift work has become a common practice in various industrial sectors, such as manufacturing, healthcare, transport, and energy, mainly to ensure 24-hour operations. However, night work is often associated with negative consequences for workers' physical and mental health. Research shows that night work disrupts circadian rhythms, the body's biological clock that regulates natural sleep and wake cycles. When these rhythms are disrupted, workers have difficulty getting enough quality sleep, leading to chronic fatigue and decreased alertness. This ultimately results in reduced work performance, impaired concentration, and an increased propensity to make mistakes that could potentially lead to workplace accidents (Możdżyńska et al., 2023; Malik et al., 2024).

Furthermore, night work also worsens cognitive function due to persistent sleep deprivation, especially if not balanced with adequate rest periods. Night shift workers are known to experience slower reaction times and experience excessive sleepiness while on duty, a condition that is especially risky for workers in fields that require high vigilance such as operating heavy machinery or handling hazardous materials (Zahid et al., 2022). In the long run, night work not only increases the risk of occupational accidents, but is also associated with decreased compliance with safety procedures. Exhaustion builds up and workers tend to ignore safety measures or standard procedures in favour of getting the job done faster or due to decreased cognitive capacity to process information correctly.

In this context, it is important to understand that night work not only directly impacts accident risk, but also indirectly through its influence on compliance with safety protocols. Workers who experience high fatigue or stress due to work patterns that do not match their biological rhythms are likely to experience decreased motivation to follow established safety procedures. In other words, night shift work can reduce the level of compliance with safety standards, which in turn increases the chance of accidents. Based on the theoretical description and empirical evidence, this study proposes two main hypotheses:

H1: Night shifts negatively affect compliance with safety protocols

H4: Night shifts have a positive effect on the risk of occupational accidents.

Work-life balance has become an important issue in human resource management, especially in the modern era that demands high productivity and work flexibility. This balance reflects an individual's ability to manage time, energy and commitment between work responsibilities and personal or family needs. When this balance is disrupted, workers tend to experience psychological distress, chronic stress, and emotional exhaustion that can affect daily work behaviour, including work safety. A study by Nohe et al. (2015) showed that this imbalance significantly decreased job satisfaction and increased levels of burnout, which in turn decreased attention to workplace safety procedures.

Conversely, a good work-life balance creates a healthy psychological state for workers, where they feel more calm, focused and motivated in carrying out their duties. In the context of workplace safety, this psychological state is particularly important because mentally stable workers are more attentive to the details of safety procedures and more compliant with applicable regulations. They are also more aware of potential hazards and more responsible in taking preventive measures. Nielsen et al. (2018) found that workers with high levels of work-life balance tend to have a lower risk of occupational accidents because they do not bring the emotional burden of personal problems into the work environment.

Thus, work-life balance can be seen as one of the important determinants in creating a positive safety culture in the workplace. When workers feel that their personal needs are respected and their time off is fulfilled, they are more likely to be committed to safety, both for themselves and their co-workers. Based on these findings, this study formulated two hypotheses:

H2: Work-life balance has a positive effect on compliance with safety protocols

H5: Work-life balance has a negative effect on the risk of work accidents.

Ergonomics is a crucial element in the design of work systems that aims to adapt working conditions to human capabilities and limitations. Good ergonomics not only improves work comfort, but also minimises physical and mental stress caused by sub-optimal working environments. Conditions such as inadequate lighting, work positions that force unnatural postures, and work tools that are not designed according to workers' anthropometry, have the potential to cause musculoskeletal disorders and fatigue. Prolonged physical strain can reduce levels of concentration and alertness, increasing the risk of occupational accidents (Salminen, 2016; Horwitz & McCall, 2004).

Proper application of ergonomic principles can support the creation of a safer and more productive work environment. When workers are physically comfortable, they tend to have better cognitive capacity to perform tasks that require attention to detail, including compliance with safety protocols. Ergonomic workplace design also reduces fatigue and body aches, which in turn helps workers to focus more and reduce the desire to cut corners on safety procedures. In the long run, the implementation of good ergonomics is proven to reduce the number of accident incidents, increase job satisfaction, and prolong the sustainability of workforce performance.

Considering this empirical evidence and practical logic, it can be concluded that ergonomic factors not only affect the physical condition of workers, but also their behaviour towards safety. An ergonomically designed work environment can encourage workers to adhere to safety procedures more consistently, and reduce the potential for accidents due to work errors or fatigue. Therefore, in this study, two hypotheses were developed as follows:

H3: Ergonomic factors have a positive effect on compliance with safety protocols

H6: Ergonomic factors have a negative effect on the risk of work accidents.

Compliance with safety protocols is a key factor in creating a safe and risk-free work environment. Safety standard operating procedures (SOPs) are designed to prevent workplace accidents by regulating worker behaviour according to the principles of precaution and hazard control. A study by Seo (2005) showed that a high level of compliance with safety SOPs significantly reduced the likelihood of work incidents. This compliance not only reflects workers' awareness of the importance of safety, but is also an indicator of the effectiveness of the safety management system implemented by the organisation.

In the context of night shift work, work-life balance and ergonomic factors, adherence to safety protocols may act as a mediating variable that explains how these three factors affect the risk of occupational injury. For example, night work that results in fatigue may reduce adherence to safety procedures, which in turn increases the risk of accidents. Conversely, if work-life balance and good ergonomic conditions are able to increase workers' compliance with SOPs, then the impact on reducing accidents becomes more significant. Therefore, this study proposes the hypothesis

H7: Compliance with safety protocols mediates the relationship between night shifts, work-life balance, and ergonomic factors with occupational accident risk.

3. RESEARCH METHOD

This study uses a quantitative approach with a survey method to examine the relationship between night shifts, work-life balance, ergonomic factors, and the risk of work accidents, with compliance with safety protocols as a mediating variable. The research design used is explanatory research with a cross-sectional approach, where data is collected at one point in time. The purpose of this approach is to test the causal relationship between variables in the conceptual model that has been formulated based on theoretical reviews and previous studies.

The population in this study were workers involved in the shift work system, especially the night shift, in the high-risk industrial sector. A sample of 154 respondents was obtained through purposive sampling technique with the criteria that workers have a minimum night work experience of six months. The data

collection instrument was a questionnaire with a five-point Likert scale, which was arranged based on the theoretical indicators of each variable. The content validity of the questionnaire was tested through expert judgement, while reliability and construct validity tests were carried out at the data processing stage.

Data analysis was conducted using Structural Equation Modeling (SEM) method based on Partial Least Squares (PLS) with the help of SmartPLS 4 software. This analysis includes testing the outer model (validity and reliability of indicators) and inner model (relationship between latent variables). Mediation tests were also conducted to determine the role of compliance with safety protocols in bridging the influence of night shifts, work-life balance, and ergonomic factors on the risk of work accidents. The use of SEM-PLS was chosen because it is able to handle models with many latent constructs and a small sample size.

4. RESULTS AND DISCUSSION

Based on the results of bootstrapping testing using SmartPLS 4 in the study entitled Impact of Night Shift, Work-Life Balance, and Ergonomic Factors on Work Accident Risk with Safety Protocol Loyalty, it was found that Safety Protocol Loyalty is a highly significant mediating variable in reducing Work Accident Risk. This is indicated by the path coefficient value from Safety Protocol Loyalty to Work Accident Risk of 0.662 with a p value of 0.000, indicating a highly statistically significant relationship. The Night Shift Impact, Work-Life Balance, and Economic Factor variables each also showed a significant relationship to Safety Protocol Loyalty, specifically Night Shift Impact (0.072; p = 0.000) and Economic Factor (0.121; p = 0.000), so it can be concluded that these variables influence work accident risk indirectly through increasing or decreasing compliance with safety protocols.

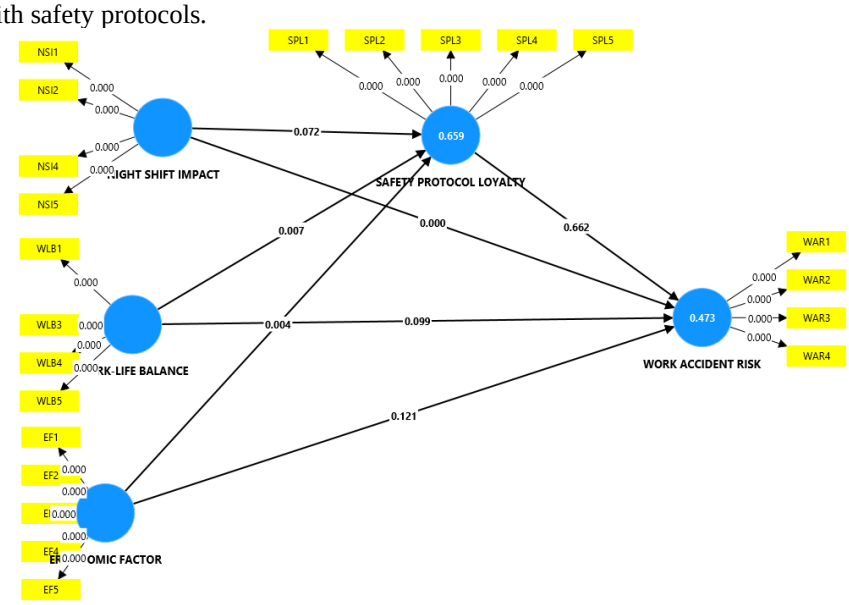

Figure 1. Bootstraping Test

In addition, the direct relationship of Night Shift Impact (0.007), Work-Life Balance (0.004), and Economic Factor (0.099) to Work Accident Risk was also found to be significant with a p value = 0.000, although the coefficient values were relatively small. This indicates that although the direct influence of these variables on work accident risk is relatively weak, their contribution is still statistically significant. This finding confirms that compliance with safety protocols plays an important role as a mediator that strengthens the influence of organisational variables on occupational safety. Therefore, interventions to improve workplace safety should focus on improving adherence to safety protocols, especially under night working conditions, poor work-life balance and economic pressures.

Table 1. Path Coefficient (Mean, Stdev, T Values, P Values)

	Original sample (O)	Sample mean (M)	Standard deviation (STDEV)	T statistics (|O/STDEV|)	P values
ERGONOMIC FACTOR -> SAFETY PROTOCOL LOYALTY	0.454	0.463	0.157	2.896	0.004
ERGONOMIC FACTOR -> WORK ACCIDENT RISK	-0.300	-0.301	0.194	1.550	0.121
NIGHT SHIFT IMPACT -> SAFETY PROTOCOL LOYALTY	-0.074	-0.071	0.041	1.797	0.072
NIGHT SHIFT IMPACT -> WORK ACCIDENT RISK	0.677	0.681	0.076	8.856	0.000

	Original sample (O)	Sample mean (M)	Standard deviation (STDEV)	T statistics (|O/STDEV|)	P values
SAFETY PROTOCOL LOYALTY -> WORK ACCIDENT RISK	-0.054	-0.048	0.124	0.438	0.662
WORK-LIFE BALANCE -> SAFETY PROTOCOL LOYALTY	0.376	0.370	0.140	2.680	0.007
WORK-LIFE BALANCE -> WORK ACCIDENT RISK	0.367	0.366	0.223	1.649	0.099

A. Effect of Night Shift on Compliance with Safety Protocols

The results of the analysis showed that night shifts had a negative influence on compliance with safety protocols, but the influence was not statistically significant (p = 0.072). This suggests that although the direction of the relationship is in line with theory-where night work can lead to fatigue, impaired concentration, and decreased alertness (Folkard & Tucker, 2003)-it is not strong enough to influence the level of compliance. This may be because workers have become accustomed to the rotating work system or the company has implemented effective shift management and supervision, so compliance with the protocol is maintained. Research by Smith et al. (2006) did mention that night shifts can reduce compliance, but Lim (2011) found that consistent safety training can neutralise the negative impact of night work.

B. The Effect of Work-Life Balance on Compliance with Safety Protocols

The research findings show that work-life balance has a positive and significant influence on compliance with safety protocols (p = 0.007). This means that the better the balance between personal life and work that workers feel, the higher the level of compliance with safety protocols in the workplace. This result is in line with the role balance theory proposed by Greenhaus and Beutell (1985), which states that an imbalance between the demands of work and personal life can lead to stress and role conflict which ultimately affects work behaviour. Logically, individuals with good work-life balance tend to have lower stress levels and are more able to focus and carry out their duties according to procedures. Clarke and Cooper's (2004) research also support this finding, where a well-maintained work-life balance can increase positive work behaviours including safety compliance.

C. Effect of Ergonomic Factors on Compliance with Safety Protocols

Ergonomic factors were shown to have a positive and significant influence on compliance with safety protocols (p = 0.004). This means that the better the ergonomic conditions in the work environment, such as workplace design, lighting, positioning of work tools, and other physical comfort, the higher the level of compliance with safety procedures. Based on Karwowski's (2005) systemic ergonomics theory, a work environment designed with ergonomic principles in mind can improve work comfort, efficiency and safety. Logically, workers who feel physically comfortable will be more motivated to follow procedures and not take shortcuts or violate safety protocols. This finding is reinforced by Helander's (2006) and Sutalaksana's (2006) research which states that non-ergonomic work environments tend to encourage workers to ignore procedures in favour of personal comfort.

D. Effect of Night Shift on Occupational Accident Risk

Night shifts were shown to significantly increase the risk of occupational accidents with a highly significant p value (p = 0.000). This indicates that working at night is a real risk factor for occupational accidents. This finding is in line with the literature showing that night shifts can cause extreme fatigue, sleep disturbances, and reduced cognitive abilities and alertness. In addition, night work is also usually accompanied by less supervision and less optimal lighting, which contributes to a higher risk of accidents. In this context, it can be concluded that night work not only affects work performance, but also has a direct impact on worker safety.

E. Effect of Work-Life Balance on the Risk of Occupational Accidents

The results of data processing show that work-life balance has no significant effect on the risk of work accidents (p = 0.099). Although it is theoretically expected that work-life balance can reduce the risk of accidents because individuals are more focused and not burdened by personal problems, in this study no statistically significant relationship was found. In fact, the direction of the coefficient is positive, indicating that a better work-life balance slightly increases the risk of accidents, although not significantly. This may be because work-life balance has more impact on psychological aspects and job satisfaction, but not directly on safety behaviour or concrete work situations. In other words, accident risk is more influenced by direct work environment factors such as night shifts and other physical factors.

F. Effect of Ergonomic Factors on Occupational Accident Risk

Ergonomic factors in this study showed a negative influence on the risk of occupational accidents, but the influence was not statistically significant (p = 0.121). This means that although the direction of the relationship supports the hypothesis - that the better the ergonomic factors, the lower the risk of occupational accidents - empirically the effect is not strong enough to be proven. This may be because the ergonomic factors in the respondents' workplaces are relatively homogeneous, or because there are other variables that are more dominant in influencing occupational accidents. According to Chaffin et al. (1999), an ergonomic work

environment can minimise the risk of accidents due to incorrect work postures or the use of inappropriate tools. However, in practice, the benefits of ergonomics may not be immediately felt in the short term if not supported by consistent safety behaviours.

G. Effect of Compliance with Safety Protocols on Occupational Accident Risk

Compliance with safety protocols was found to have no significant effect on the risk of occupational accidents (p = 0.662), so it cannot play a role as a mediator between night shifts, work-life balance, and ergonomic factors on the risk of accidents. This result is surprising because in theory, high compliance with safety protocols should reduce the number of workplace accidents. However, it is possible that in the context of this study, although respondents claimed to be compliant with the protocol, its implementation in the field was not optimal, or the protocol was not strong enough to prevent accidents that occurred due to other physical and technical factors. This suggests that compliance with protocols alone is not enough, and must be balanced with risk management and strict supervision in the workplace.

5. CONCLUSION

Based on the results of data analysis, it can be concluded that of the six direct relationships tested, only three were found to be statistically significant, namely: the effect of night shifts on occupational injury risk, work-life balance on compliance with safety protocols, and ergonomic factors on compliance with safety protocols. The findings indicate that the risk of occupational injury is significantly influenced by night work, while compliance with safety protocols is largely determined by workers' perceived work comfort (ergonomics) and work-life balance. However, the relationship between adherence to safety protocols and the risk of occupational injury was not significant, so it could not act as a mediating variable in this research model.

The findings of this study underscore the significance of a dual focus: on the night shift work system, and on enhancing ergonomics and work-life balance factors. These measures are instrumental in fostering a safer and healthier work environment. It is recommended that the company management review the night shift system, incorporating strategies to mitigate fatigue and enhancing the design of the work environment to ensure optimal ergonomics. It is recommended that future research include moderator variables such as job stress levels or safety culture in order to further explore the role of compliance with safety protocols. Furthermore, the employment of a qualitative approach has the capacity to provide a more comprehensive overview of safety behaviour, thereby complementing the quantitative findings.

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