



The Effect of Fatigue on Safety Attitude, Hazard Recognition and Safety Risk Perception among Construction Workers

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ABSTRACT: According to the National Job Institution, each year about 360 million job accidents happen all around the world which leads to the loss of lives of over two million people. About 50% of these accidents are related to the construction sector which causes physical, mental, and monetary damages. Therefore, to prevent and decrease incidents in construction environments, it is essential to explore the factors that influence safety attitude, hazard recognition performance, and safety risk perception of construction workers. One of these factors is fatigue, which has a negative effect on the safety performance of construction workers but has not been empirically investigated before. To study the impacts of fatigue on the safety performance of construction workers and achieve the research goals, 135 construction workers were recruited. After collecting fatigue data and safety attitudes of the participating workers, their hazard recognition and safety risk perception were evaluated using pre-evaluated case images all captured from real construction projects. The results of the study revealed that (1) in comparison with high fatigue levels, low fatigue levels are associated with a more positive safety attitude and higher hazard recognition, and (2) the effect of fatigue on safety risk perception was mediated by hazard recognition performance and safety attitude. The findings of this study help the construction industry to improve safety performance by mitigating the negative aspects of fatigue among workers.

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1. INTRODUCTION

Construction is one of the most hazardous industries in the world. Only 7% of workers are employed in construction but the industry accounts for an estimated 30-40% of fatalities. In fact, the fatality rate of construction is fourfold more than other industries such as oil and gas, transportation, and mine industries [1-3]. Accident analyses show that the main factors leading to these accidents can be attributed to the nature of this industry (e.g., hazardous and demanding activities and dynamic environment), human behavior, and workplace characteristics [4]. It has been reported that 80 to 90% of accidents in labor environments are because of workers' unsafe behaviors [5]. However, most construction accidents can be prevented by identifying, evaluating, and controlling potential hazards [6]. Workers who fail to identify hazards in their workplaces or underestimate the associated safety risks are less likely to take preventive actions and control hazards that they are exposed to in their workplaces [7]. On the other hand, as shown in Fig. 1, when the hazards and safety risks are properly recognized and perceived, workers are more prone to control the hazards by corrective actions and adopting safe and efficient behaviors [9]. Furthermore, workers' attitude towards safety in the workplace, has been identified as one of the most effective factors that impact the safety performance

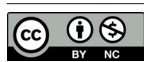
of construction workers [10]. There is scarce research in this area – especially in the construction industry demonstrating the interrelationship among these key factors. Therefore, the purpose of the present research is to evaluate the relationships between fatigue, safety attitude, hazard recognition, and safety risk perception among construction workers.

2. RESEARCH METHOD

To test the proposed hypotheses, the data of 135 recruited construction workers in 48 active projects in Iran were gathered. These projects included residential (63.7%), commercial (17%), industrial (6.7%), and infrastructure (12.6%). The approached projects were located in Hamadan (29.6%), Yasouj (20.7%), Tehran (18.5%), Shiraz (15.6%), Gachsaran (8.1%), and Zanjan (7.4%). The participants' age and job experience ranged from 21 to 58 ($M = 37$) and 5 to 36 ($M = 19$), respectively. Among the workers, only 24 workers (18%) asserted that they have received formal safety training.

Upon the completion of gathering demographic information, with the permission of the on-site project manager, workers were randomly selected and interviewed. The fatigue level, safety attitude, and safety performance of the participants were gathered in four complementary and separate stages during one site visit. First, the fatigue level of each worker was gathered by using a widely-adopted

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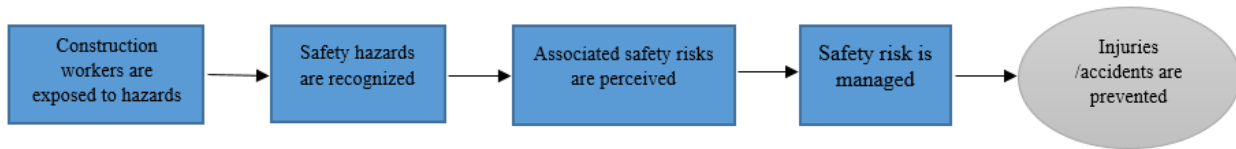


Fig. 1. Conceptual accident prevention process [8]

Table 1. The structural model of the total effect of fatigue on safety risk perception

| Indirect Relationships | Indirect Coefficient | T-Value | P-Value | Bootstrap Confidence Interval | |
|---|----------------------|---------|---------|-------------------------------|------------|
| | | | | LLCI 2.5% | ULCI 95.5% |
| The mediating roles of safety attitude and hazard recognition performance in the relationship between fatigue level and safety risk perception (FL → SA → HR → SRP) | -0.194 | 3.906 | 0.001 | -0.306 | -0.104 |

subjective fatigue scale (OFER) [11]. Next, the participants answered 10 validated questions to measure their safety attitude using an 11-point Likert Scale.

After gathering data related to workers’ fatigue and safety attitude, workers’ hazard recognition ability and safety risk perception were measured using case images all pre-evaluated by a specialized council of experts. In each stage, workers voluntarily and anonymously participated in the study and they were assured that their information will be confidential but only used for promoting construction safety [12].

3. RESULTS AND DISCUSSION

Phase I: Direct effect

The results showed a statistically significant correlation between workers’ fatigue and safety attitude ($\beta = -0.47$; T-Value= 6.2; $p < 0.001$). Also, a negative effect of workers’ fatigue on their hazard recognition performance was observed ($\beta = -0.35$; T-Value= 3.88; $p < 0.001$). In addition, the data analysis showed a significant positive correlation between workers’ safety attitude and hazard recognition ($\beta = 0.47$; T-Value= 6.58; $p < 0.001$). Finally, the results indicated the direct impact of hazard recognition on workers’ safety risk perception ($\beta = 0.86$; T-Value= 30.34; $p < 0.001$).

Phase II: Indirect effect

The research revealed that safety attitude had a mediating role in the relationship between fatigue and hazard recognition performance (Indirect Coefficient= -0.225; T-value= 4.42; $p < 0.001$). However, the results demonstrated that the relationship between fatigue and safety risk perception was mediated by hazard recognition operation (Indirect Coefficient= -0.303; T-value= 3.86; $p < 0.001$). Finally, hazard recognition performance mediated the relationship between safety attitude and safety risk perception (Indirect Coefficient= 0.41; T-value= 6.33; $p < 0.001$).

Phase III: The total effect

In this model, a structural analysis and hypothesis testing of the total effect of fatigue on safety risk perception were

conducted. As shown in Table 1, the total effect of safety attitude and hazard recognition performance on the relation between fatigue and safety risk perception was statistically significant and negative (Indirect Coefficient= -0.194; T-value= 3.906; $p < 0.001$).

4. CONCLUSION

The analysis of the data revealed a negative correlation between workers’ fatigue, safety attitude, and hazard recognition performance. More specifically, by decreasing fatigue levels, workers will have a more positive safety attitude and higher levels of hazard recognition performance. In addition, the results showed that fatigue affects safety risk perception and this relationship is mediated by safety attitude and hazard recognition performance. In other words, workers who have higher fatigue levels, more negative safety attitudes, and lower hazard recognition performance, are more likely to underestimate the associated safety risk and therefore, more likely to be involved in an occupational accident.

Overall, the findings demonstrated that fatigue can adversely affect the safety performance of construction workers and contribute to increased human error. The study identified that only 19.4% of fatigue and safety risk perception variability is explained to safety attitude and hazard recognition. Therefore, future efforts must focus on identifying and evaluating other influencing factors that impact the safety performance of construction workers.

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