Neuroergonomics and Cognitive Engineering, Vol. 126, 2024, 180–187
https://doi.org/10.54941/ahfe1004751

Assessing the Effects of Fatigue on Cognitive Performance in Shift Workers in the Petrochemical Industry: A Scoping Review

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ABSTRACT

Each industry has its challenges and risk factors for workplace fatigue, shaped by the nature of the work, the work environment, and regulatory frameworks. The petrochemical industry requires shift systems to keep their productions operational continuously. These systems pose significant risks associated with worker fatigue. Workers are frequently exposed to hazardous chemicals, posing a risk to their health and further exacerbating fatigue. It might lead to decreased safety and productivity. To investigate this issue, we conducted a scoping review of literature published according to PRISMA guidelines in the past two decades using Scopus, Web of Science, and Embase databases. The objective is to investigate the question: "What does the current literature indicate about the effects of fatigue during shift work in the petrochemical industry?". Our review highlights the complex relationship between shift work patterns and their physiological and psychological impact on workers in this industry. Our paper aims to provide industry-specific recommendations and interventions that effectively reduce the adverse effects of shift fatigue in the petrochemical sector.

Keywords: Fatigue, Ergonomics, Petrochemical, Stress, Human factors

INTRODUCTION

Shift work is commonly adopted globally among both part-time and full-time employees. It usually involves hours extending beyond the standard 07:00 to 18:00 timeframe. It impacts nearly 20% of the global labor force (Rivera et al., 2020, Wright et al., 2013). Fatigue, although lacking a universally accepted definition, is described by The Oxford Dictionary as "*extreme tiredness resulting from mental or physical exertion*" distinct from sleepiness or tiredness. Sleep might mitigate sleepiness but does not necessarily relieve fatigue, which can occur without sleepiness (Phillips, 2015, Shen et al., 2006). This distinction is crucial as Shen et al. (2006) noted the significant effect of shift work on subjective fatigue, unlike sleepiness, suggesting the need for different assessment and management approaches. Gander et al. (2011) highlighted fatigue as a critical issue in workplace risk management.

Heidari et al. (2017) identified job satisfaction, mental disorders, and sleepiness as critical factors affecting fatigue, employing the Seemingly

Unrelated Regression (SUR) method. Moradifar et al. (2014) demonstrated that rotating-shift workers exhibit higher fatigue levels and greater insomnia severity than their fixed-dayshift counterparts.

The petrochemical industry, which converts petroleum and natural gas into various chemical products, had experienced significant growth since the first petrochemical product was produced in 1920 at the Standard Oil plant in Bayway, New Jersey, when isopropyl alcohol was successfully produced (AFPM_Communications, 2020). Since then, continuous production schedules have necessitated shift work, leading to irregular sleep patterns and chronic fatigue. The complexity of manufacturing processes, the need for constant vigilance, and exposure to hazardous chemicals exacerbate workers' mental and physical exhaustion.

However, different industries face unique challenges and risks associated with workplace fatigue, influenced by the nature of the job, the environment, and the regulations. This scoping review aims to evaluate the current research on fatigue's effects on cognitive functions among shift workers in the petrochemical industry.

METHODOLOGY

The methodology for this research was structured to ensure a comprehensive review of relevant literature. In conducting this scoping review, the 2020 Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA) guidelines (Page et al., 2021) was followed. This approach ensured a rigorous and transparent review process, facilitating a comprehensive understanding of the impacts of work shifts and fatigue in the petrochemical sector.

The initial phase involved setting specific parameters for database searches: a focus on the petrochemical sector and published research between January 1990 to December 2023, utilizing prominent databases of Scopus, Web of Science, and Embase.

This review focused on the relationship between work shifts and fatigue within the petrochemical industry. A strategic combination of keywords were employed to capture the breadth of relevant literature, including both MESH and non-MESH terms: 'Petrochemical,' 'work shift,' and 'fatigue'.

Two reviewers independently assessed the titles and abstracts of citations gathered from all sources. Disagreements between the two reviewers were resolved through consultation with additional authors. The synthesis of the findings from these studies is presented in Table 1.

RESULTS

A comprehensive search yielded 40 relevant papers. After removing duplicates, the remaining articles underwent a careful selection process. Adhering to predefined inclusion and exclusion criteria, 8 articles were ultimately deemed suitable for inclusion in the final analysis (refer to Figure 1).

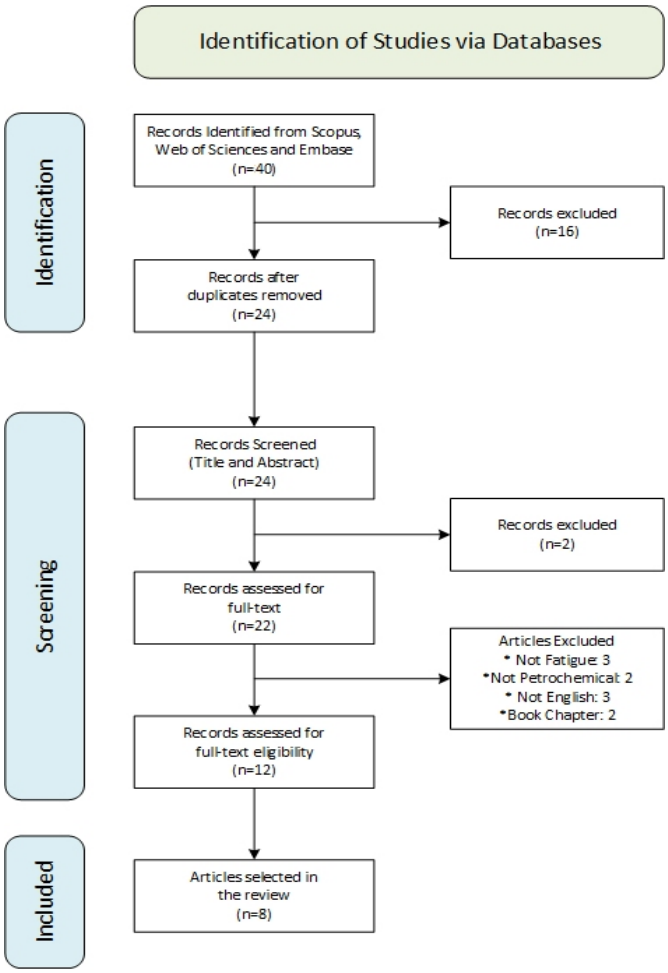

Figure 1: Detailed flowchart illustrating the study selection process for the scoping review.

DISCUSSION AND CONCLUSION

The scoping review conducted recently has brought to light some significant findings regarding the impact of fatigue on cognitive performance of shift workers in the petrochemical industry. It highlights the complex occupational health challenges faced by these workers. The collected studies present a comprehensive picture of how shift work can adversely affect both mental and physical health, leading to decreased cognitive performance and an increased risk of human errors in high-stakes environments. The studies provided understanding of how shift work can adversely affect mental and physical health, leading to decreased cognitive performance and increased risk of human errors.

The investigation made by researchers like Bazazan et al. (2019), Choobineh et al. (2018), and Fischer et al. (2000) had conducted investigation on the complex dynamics between shift work schedules, sleep quality,

and worker fatigue. For instance, Bazazan et al. (2019) found a significant correlation between physical and mental fatigue, suggesting that mental health could significantly contribute to increased fatigue among workers. This aligns with Choobineh et al. (2018), who emphasized increased levels of fatigue and sleepiness in employees with sleep disorders, particularly those on irregular or night shifts. Adding to the complexity of this issue, research conducted by Fischer et al. (2000), (Kazemi et al., 2016) and Kazemi et al. (2018) demonstrated the adverse effects of inadequate sleep and long working hours on shift workers' circadian rhythms and cognitive functions. These consequences are not only limited to decreased alertness and cognitive performance but also include psychological discomfort and increased risk of human errors (Mariana et al., 2018, Rasoulzadeh et al., 2015).

Ultimately, the reviewed body of research suggests a new approach to address the issues triggered by shift work in the petrochemical industry. Based on the collected evidence, interventions must not only focus on adjusting shift schedules and work hours to align with the human biological clock alone but also stress the importance of regular health assessments, mental health support, and strategies to improve sleep quality among workers. Kang et al. (2021) analyzed various studies to categorize and compare fatigue assessment methods in the industry.

The scoping review has revealed a significant gap in our understanding of how shift work affects the mental health and overall performance of workers in the petrochemical industry. Although the research reviewed has drawn connections between shift patterns, fatigue, sleep quality, and cognitive performance, it seems we still missing in-depth research to explain the causes of the marked decline in cognitive performance and increased fatigue related to different shift patterns. Additionally, there is a marked gap in the lack of literature exploring individual differences, such as age, cultural background, and worker experiences.

The impact of shift work has been studied across various industries, and fatigue is a widespread issue. In the Malaysian electronics manufacturing industry, Shahril Abu Hanifah and Ismail (2020) noted a high prevalence of fatigue. Boogaard and Caubo (1994) examined the relationship between physical workload, shift work, and health and suggested that changes in circadian rhythms due to shift work, rather than chemical exposure, were responsible for increased albuminuria in industrial workers. Parody et al. (2020) highlighted the different types of fatigue (physical, mental, and general) and their influence on worker performance in an energy accumulator assembly line.

The authors Richter et al. (2016) have reviewed non-pharmacological measures to combat fatigue and suggested several coping strategies for workplace health promotion programs, including napping, exposure to bright light, and cognitive-behavioral measures. Dawson and Reid (1997) have compared the performance impairment caused by fatigue with that of alcohol intoxication, thus highlighting the significant risks associated with fatigue in workplace safety assessments.

Table 1. Summary of the selected papers.

Authors, Year	Country	Purpose of the Study	Study Design	Study Population	Summary of Findings
Bazazan et al. (2019)	Iran	Evaluated the prevalence of mental health concerns and fatigue among 8 -hour rotating shift workers in petrochemical industries in Iran.	Questionnaire survey	287	Occupational fatigue and mental health complaints among 8 - hour shift workers of petrochemical industries in Iran. The results showed a strong positive correlation between physical and mental fatigue in shift workers, suggesting that higher levels of mental health issues were associated with higher levels of fatigue.
Choobineh et al. (2018)	Iran	Assessed the prevalence of fatigue, sleepiness, and sleep disorders among petrochemical employees in Iran, and to investigate the relationship between these factors.	Cross-sectional design- Questionnaire survey	501	The prevalence of fatigue, sleepiness, and sleep disorders among Petrochemical employees reported moderate levels of fatigue, with significant differences in fatigue dimensions between individuals with and without sleep disorders. Positive relationships between sleepiness and fatigue among petrochemical workers. Shift workers had higher fatigue scores compared to day workers. Employees with sleep disorders had significantly higher levels of fatigue and sleepiness compared to those without sleep disorders. Rest, plays a role in the occurrence of fatigue among these workers
Fischer et al. (2000)	Brazil	Evaluated the impact of implementing 12 -hour shifts in a Brazilian petrochemical plant on workers' sleep duration, sleep quality, and alertness.	Questionnaire	218	Sleep duration decreased during night shifts and increased after off days. Sleep quality was perceived to be worse after night shifts compared to day shifts. Perceived alertness was higher during the early hours of the shift and decreased in the later hours.
Kazemi et al. (2016)	Iran	Examined the effects of shift work on cognitive performance, sleep quality, and sleepiness among petrochemical control room operators	questionnaire survey	60	Long working hours per shift result in significant fatigue, which in turn causes irregularities in the circadian rhythm and the cycle of sleep. This fatigue induced a decline in cognitive performance at the end of both day and night shifts. Fatigue associated with shift work, especially during long shifts, is a critical factor contributing to the observed decrease in cognitive functions among petrochemical control room operators.

(Continued)

Table 1. Continued

Authors, Year	Country	Purpose of the Study	Study Design	Study Population	Summary of Findings
Kazemi et al. (2018)	Iran	Investigated the effects of night shifts on cognitive performance, salivary melatonin levels, and sleep among control room operators in a petrochemical complex.	questionnaire survey	60	Cognitive performance was better among workers in the 7 -night shift compared to the 4 -night shift. Melatonin levels and sleepiness were not significantly different between the two shift types, but there were significant effects of time and shift duration on these factors.
Mariana et al. (2018)	Indonesia	Investigated the impact of fatigue on human errors in the workplace	questionnaire survey	37	Fatigue and human errors analysis in petrochemical and oil and gas plant's operation found that there are association between fatigue and human errors among shift workers in petrochemical, oil, and gas plant operations.
Rasoulzadeh et al. (2015)	Iran	Examined the levels of psychological distress and fatigue among petrochemical workers on 12-hour shift schedules.	cross-sectional study-Questionnaire survey	290	The were an association between fatigue and psychological discomfort, especially among those working 12-hour shifts.
Sadeghniiat Haghighi et al. (2018)	Iran	evaluate the sleep quality of offshore workers in the petroleum industry, specifically focusing on factors such as shift schedule, job satisfaction, and age.	cross-sectional study-Questionnaire survey	192	More than half of offshore workers in the petroleum industry had poor sleep quality, with workers on fixed night shifts having the highest scores on Sleep Quality. Factors such as age, job satisfaction, and shift schedule were associated with impaired sleep quality.

Fathi et al. (2013) have discussed the challenges of shift work in Iran, such as stress and job dissatisfaction, and have emphasized the need for ergonomic measures to mitigate these adverse effects.

Finally, Bourdouxhe et al. (1999) conducted a study on the long-term effects of shift work, specifically rotating 12-hour shifts. The study warns of future concerns, especially for aging workforces, in managing the compounded effects of shift work.

In conclusion, the findings from this scoping review necessitates developing a new approach to investigating the health and safety of shift workers in the petrochemical industry. It is essential to optimize the design of work activities for shift workers by considering their cognitive load and capacity. This includes rethinking shift designs and implementing health and wellness programs to mitigate the risks of shift work. By prioritizing employees' health, petrochemical industries can enhance productivity and overall workplace satisfaction.

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