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FATIGUE RISK FACTORS OF OFFSHORE OIL AND GAS WORKERS
A Systematic Review

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KEYWORDS
Occupational Fatigue, Offshore, Oil and Gas

ABSTRACT
Many offshore oil and gas workers experience fatigue due to shift work schedules, excessive working hours, lack of sleep, heavy workloads, and harsh environmental factors. Fatigue has the potential to impact an individual's performance, alertness, and overall health and safety. The objective of this research is to identify risk factors for fatigue in offshore oil and gas workers so that preventive measures can be taken. This research is a systematic review using PRISMA (Preferred Reporting Items for Systematic Review and Meta-Analysis) to identify, select, and synthesize studies. Search via the central database, namely ScienceDirect. The publication period used is 2017-2024 with the keywords "Occupational Fatigue" AND "Offshore" AND "Oil and Gas". This research produced eight journals with a Q1 rating. The risk factors for fatigue in workers consist of four risk factors: environmental, organizational, psychosocial, and individual.

INTRODUCTION

The risk of offshore oil and gas operations is very high. Several accidents that caused fatality, environmental pollution, and financial losses occurred in various places. Fatigue is one of the contributing factors causing accidents such as the Piper Alpha accident in 1988 in the North Sea and the Deepwater Horizon in the Gulf of Mexico in 2010. (Shortz, A.E et al, 2019, Dahlan A., 2022)

Offshore workers are exposed to two risk factors, namely environmental and psychosocial. Physical environmental factors such as noise, poor air quality, vibration, hot air, heavy physical activity, dangerous chemicals, and seasickness. Psychosocial factors due to isolated work locations and limited accommodation facilities cause workers to have to work for long periods of 2 weeks or more at work and 2 weeks or more rest at home. Long work schedules and working at night have the potential to cause fatigue. The combination of these two risk factors has an impact on decreased performance and the potential for accidents. (HSE UK, 2010). Increasing the duration of work shifts has the potential to increase fatigue, especially at the end of the shift period (Riethmeisteram, V., 2018). Fatigue has an impact on occupational health, performance and safety. **(**Alroomi, U.S., 2021, Benson, C., 2021).

Fatigue can cause decreased cognitive performance, sleep disturbances, depression, anxiety, decreased alertness, attention, and mental function, as well as slowed reaction times and reduced situational awareness. This can lead to human errors, such as negligence, mistakes, and violations, which can increase the risk of workplace accidents and injuries. (Dahlan, A., 2022, S. Pavičić Žeželj 2019, Benson. C, 2021).

This decline in performance contributes to two risks, namely operational risk and worker risk. Operational risks such as fire, equipment damage, and termination of operations due to worker error. Worker risks related to the physical, mental, and welfare conditions of workers due to injury, illness, sleep disturbances, and worry. The risk to workers can be more serious

if family problems are added due to the long-term absence of workers while working offshore. (HSE UK, 2010)

Working at isolated offshore oil and gas facilities requires workers to work long hours and shift work patterns. This work pattern causes two fatigue effects. First, the direct effect of lack of brain synchronization during normal sleep times but being on a work schedule that demands full concentration, and second, the effects of lack of sleep itself due to poor sleep quality. (Ross, J., 2009)

Physical fatigue affects worker safety because it reduces the worker's cognitive ability to process hazard information when the worker's situational awareness is reduced. Fatigue and decreased alertness due to lack of sleep or poor sleep quality have the potential to cause accidents due to slow reaction times, reduced alertness, reduced decision-making ability, decreased ability to analyze when carrying out complex tasks, and loss of awareness in critical situations. (HSE UK, 2018).

Fatigue has an impact on reducing the ability of workers who have critical roles related to safety to cognitively evaluate critical conditions. Concentration for anticipation and proactive planning becomes unfocused. Furthermore, there is a decrease in alertness and increases the risk of accidents. There is a strong link between fatigue and decreased cognitive function such as slower reactions, ability to process information, decreased memory, experiencing confusion and decreased concentration. This condition has the potential to cause accidents. (IPIECA-IOGP, 2019)

RESEARCH METHOD

This research uses PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analysis) to identify, select, and synthesize studies. Search via the central database, namely ScienceDirect. The period used is 2017-2024. The keywords used are "Occupational Fatigue" AND "Offshore" AND "Oil and Gas".

The inclusion criteria in this systematic review research are: 1) The research article uses a cross-sectional or cohort study, and 2) The article has been published in the 2020-2023 period. 3) Open access free full text for easy access in PDF file form, 4) Research articles related to risk factors for fatigue in offshore oil and gas workers, 5) articles in English.

The exclusion criteria in this systematic review research are 1) systematic review or review article. 2) There is no discussion of risk factors for fatigue in offshore oil and gas workers.

RESULTS AND DISCUSSION

Based on article search results using one database, in the 2017-2024 publication period with the keywords "Occupational Fatigue" AND "Offshore" AND "Oil and Gas".

Get 478 articles from ScienceDirect. The articles were then filtered based on the years 2017-2024 and 187 articles were obtained. Next, it was filtered again based on the research article inclusion factor, resulting in 93 articles. Next, filtered using the Occupational Fatigue Offshore Oil and Gas inclusion factor, 15 articles were obtained. The screening continued by looking at the objectives and methods and a total of eight articles with a Q1 rating were obtained which could be analyzed and discussed risk factors associated with fatigue in offshore oil and gas production facilities.

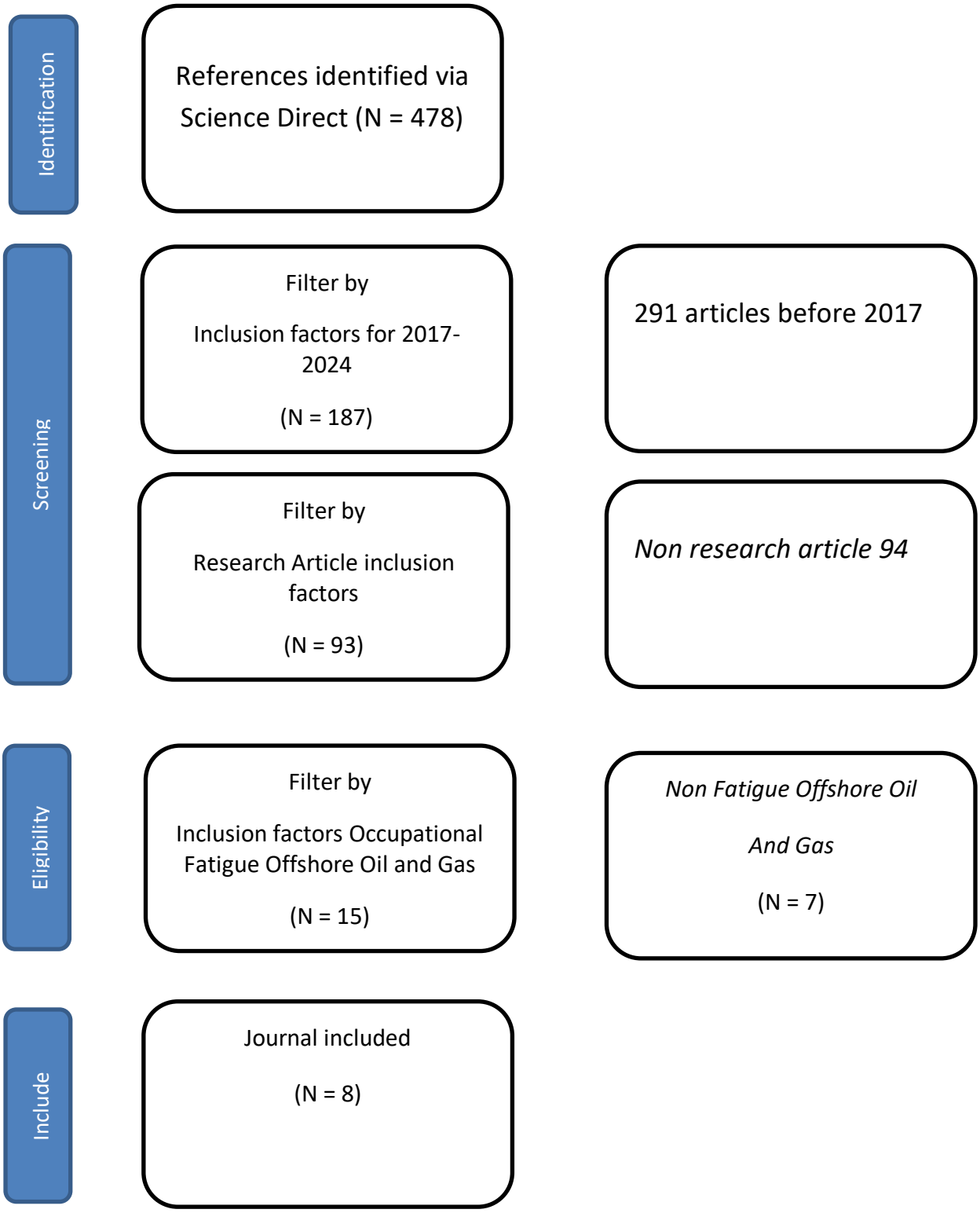
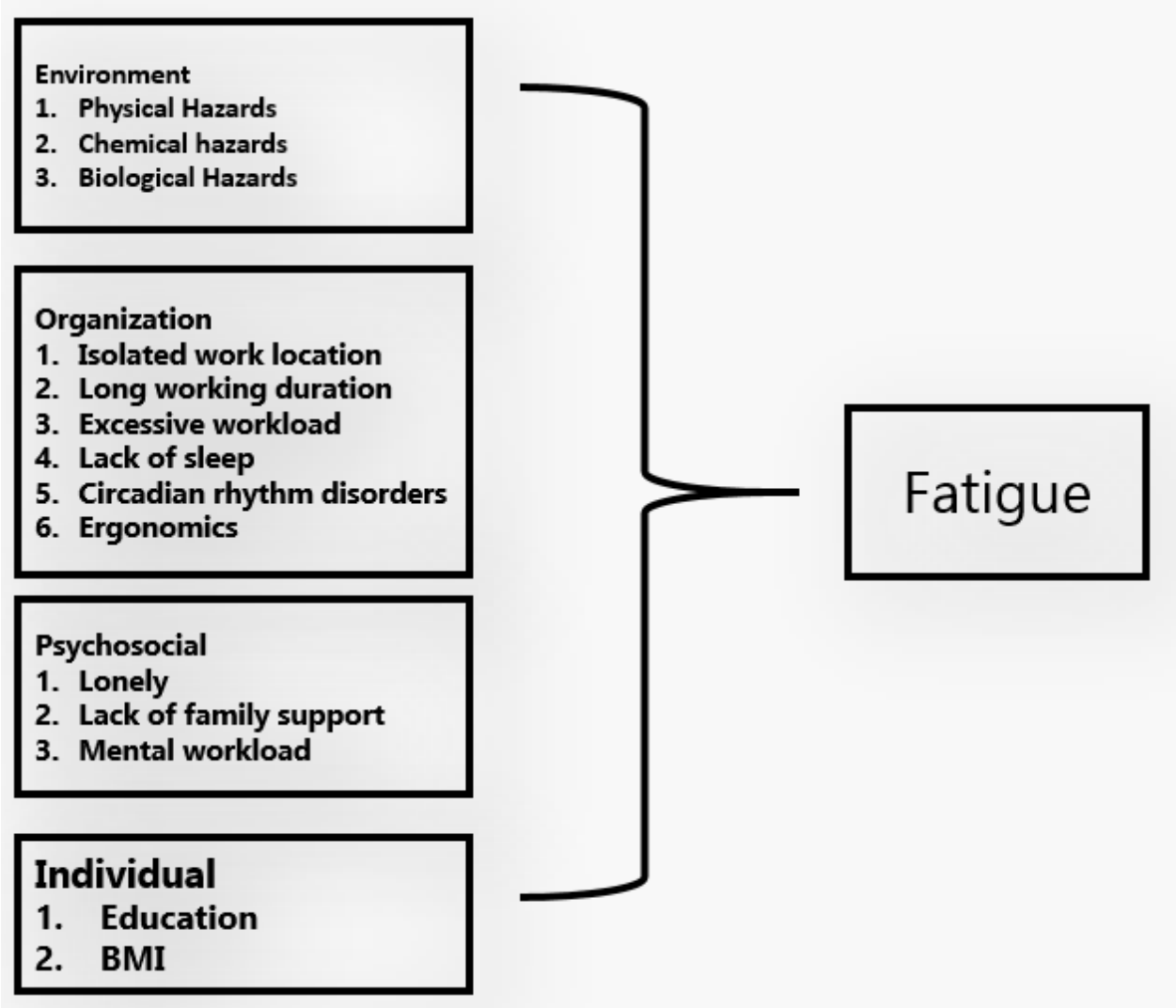


Table 1. Summary of research results related to fatigue risk factors

Based on the 8 articles above, several risk factors for fatigue in workers were found which were divided into four risk factors, namely environmental risk factors, organizational risk factors, psychosocial risk factors, and individual risk factors (Figure 1). Environmental risk factors include physical, chemical, and biological hazards. Organizational risk factors are

isolated work locations, long work duration, excessive workload, lack of sleep, circadian rhythm disorders, and ergonomics. Psychosocial risk factors are loneliness, lack of family support, and mental workload. Individual factors, namely education level and body mass index (BMI).

Fatigue Risk Factors



Publication Identification	Research Objectives and Methods	Result
1. Title: Does fatigue mediate the relationship between physical isolation and safety behavior among isolated oil and gas workers? Author: Anwar S. Alroomi, Sherif Mohamed Journal Name/Year/Rating: Safety Science/2021/Q1	The objective of this study was to investigate the relationship between physical isolation, fatigue, and safety behavior among workers on oil and gas projects in Kuwait. Methods: a cross-sectional study with N=387 people	1. There is a correlation between social isolation, loneliness, fatigue, and safety behavior 2. Risk factors for fatigue Job factors: isolated workplace Psychosocial factors: Loneliness, mental stress

2. Title: Field-based longitudinal evaluation of multimodal worker fatigue assessments in offshore shiftwork Author: John Kang , Stephanie C. Payne , Farzan Sasangohar, Ranjana K. Mehta/ Journal Name/Year/Rating: Applied Ergonomic/2023/Q1	The objective of this study was to assess fatigue in offshore workers in the oil and gas industry using subjective, performance-based, and physiological measures. The research method used was longitudinal on 70 drilling ship workers for four weeks. Subjective and objective measurements	1. There is a correlation between various measures of fatigue, including subjective, performance-based, and physiological measures. There is a positive correlation between the influence of rotating work shifts and fatigue. 2. Risk factors for fatigue: Job Factors: shift work, high workload, sleep deprivation, and circadian rhythm disorders
3. Title: Investigating daily fatigue scores during two-week offshore day shifts. Author: Vanessa Riethmeistera, Ute Bültmanna, Marijke Gordijnb, Sandra Brouwera, Michiel de Boerc Journal Name/Year/Rating: /Applied Ergonomic/2018/Q1	The objective: measure fatigue before and after a shift to understand how fatigue and circadian rhythms change over long periods of work. Methods: a prospective cohort of 60 people.	1. 1. Objective daily fatigue scores, pre- and post-shift, remained stable over a two-week offshore day shift period. But post-shift subjective fatigue scores improved significantly. No significant changes in circadian rhythm markers were found. 2. Risk factors for fatigue: Job factors: long work duration, lack of adequate sleep, and high work demands. Psychosocial Factors: psychosocial effects of the “third quarter phenomenon” i.e. significant changes in mood and performance caused by monotony, boredom, and limited social contact.
4. Title: Comparison of objective and subjective operator fatigue assessment methods in offshore shiftwork Author: Ranjana K. Mehta , S. Camille Peres , Pranav	Objective: to assess the level of fatigue of operators on drilling vessels during their work shift using objective and subjective methods. Method: cross-sectional study through quantitative	1. The operator's physiological response is higher during active movement activities compared to passive activities. Subjective and objective measurements do not always agree.

Kannan , Joohyun Rhee, Ashley E. Shortz , M. Sam Mannan Journal Name/Year/Rating: Journal of Loss Prevention in the Process Industries/2017/Q1	data collection through subjective fatigue evaluation and objective physiological monitoring of 10 participants (N=10).	2. Occupational risk factors: intensive work shift patterns, long work duration, as well as physical workload, ergonomics, lack of sleep or poor sleep quality and the 24-hour circadian cycle in alertness and awareness. Psychosocial Factors: Mental workload
5. Title: Physical isolation and safety behavior among oil and gas workers in Kuwait: The mediating role of mental health Author: Anwar S. Alroomi, Sherif Mohamed Journal Name/Year/Rating: Journal of Loss Prevention in the Process Industries/2021/Q1	The objective: to examine the relationship between physical isolation variables (social isolation and loneliness), mental health (anxiety and depression), and safety behavior Method: a cross-sectional study of 387 workers	1. Physical isolation, which includes social isolation and loneliness, harms worker safety behavior. 2. 2. Risk factors for fatigue: Job factors: workload pressure, high responsibility, lack of sleep. Psychosocial Factors: social isolation and lack of family support
6. Title: Time-of-day and days-on-shift predict increased fatigue over two-week offshore day-shifts Author: V. Riethmeistera, R.W. Matthews, D. Dawson, M.R. de Boere, S. Brouwer, U. Bültmanna Journal Name/Year/Rating: Applied Ergonomics/2018/Q1	Objective: to investigate how fatigue accumulates in offshore workers over a two-week work period and to understand the influence of acute and chronic sleep loss on the rate of accumulation of such fatigue. Methods: prospective cohort study involving 42 offshore workers working day shifts for two weeks.	1. Fatigue after a shift increases faster than fatigue scores before a shift. Sleep loss, whether acute or chronic, impacts the rate of fatigue accumulation over two weeks. 2. Risk factors for fatigue: Work factors: accumulated fatigue over a two-week work period, workload pressure, lack of sleep.
7. Title: Physical and psychological job demands and fatigue experience among offshore workers. Author : Ahmad Bazazan , Yousuf Noman , Hadis Norouzi, Azam Maleki-Ghahfarokhi,	The objective: to evaluate physical and psychological job demands and their relationship to burnout among offshore oil and gas workers. Method: a cross-sectional study of 251 workers	1. Physical job demands, psychological factors, BMI, education, and task interference are associated with general fatigue. 2. 2. Fatigue risk factors: Individual factors: BMI and education level. Job

Parvin Sarbakhsh, Iman Dianat Journal Name/Year/Rating: Heliyon Journal/2023/Q1		factors: ergonomic physical work demands, excessive workload. Psychosocial factors: task interference by other people.
8. Title: Assessing the common occupational health hazards and their health risks among oil and gas workers. Author: Chizubem Benson, Christos Imopoulos, Christos D. Argyropoulos, Cleo Mariano Mikellidou, Georgios Boustras Journal Name/Year/Rating: Safety Science/2021/Q1	The objective: identify various health hazards and risk factors in the oil and gas industry to determine the risks associated with these health hazards. Method: a cross-sectional study of 327 workers.	1. Ergonomic hazards are the most dominant among the hazards assessed, followed by physical, chemical, psychosocial, and biological hazards. Workers in this industry face a variety of health effects due to these hazards

DISCUSSION

The relationship between environmental factors and fatigue

Environmental factors consisting of physical, chemical, and biological factors are positively correlated with fatigue. (Benson et al, 2021, Kurniawidjaja, 2019). Physical factors are high temperature, dusty environment, poor air quality, noise, lack of light, and vibration (Ramdan et al, 2018, Susilowati I.H, 2013, Dahlan A., Baiduri W., 2022). Chemical factors, namely gas and oil contain acid gases such as H2S, and CO2 and use of chemicals used for operational purposes such as benzene, toluene, and xylene. Biological factors, namely the potential for food poisoning, parasites, viruses, and bacteria. (Benson et al, 2021)

The relationship between organizational factors and burnout

Organizational factors such as high work demands, long work schedules of more than 12 hours, irregular work schedules, suboptimal sleep quality, and extreme workloads greatly influence fatigue. (Caldwell, John A. 2015). Two weeks work shift and two weeks off (2:2 system), especially on the last day of the work shift, which causes accumulation of fatigue plus workload pressure, and lack of sleep will increase the risk of fatigue. (Riethmeistera, V. et al, 2018, Yeboah B., et al, 2021).

Intensive work shift patterns, long work duration, as well as physical workload, ergonomics, lack of sleep or poor sleep quality, and disruption of the 24-hour circadian cycle reduce alertness and awareness (Mehta, R.K, 2017). Ergonomic factors such as repetitive movements, awkward working positions, standing for long periods, manual handling, and working at heights increase the risk of fatigue. (Benson C. et al, 2021)

Lack of sleep can have a significant impact on fatigue. When a person doesn't get enough sleep, it can lead to decreased mental alertness and increased sleepiness, both of which can negatively affect performance, especially during times when the body naturally desires sleep. Circadian rhythm disruption can have a significant impact on fatigue. Circadian rhythm is the body's natural cycle that regulates the sleep-wake cycle and is influenced by light and dark. Disruption of circadian rhythms can lead to decreased alertness and increased sleepiness, both of which can negatively affect a person's performance. (IPIECA-IOGP, 2019).

The relationship between psychosocial factors and fatigue

Remote offshore work locations cause feelings of loneliness and the absence of normal interactions with a network of friends and family can increase the risk of burnout. (Anwar Alroomi, A. S., 2021. Other psychosocial problems that can cause fatigue are excessive work demands, lack of support from superiors and coworkers, lack of role in the organization, and social aspects. (Bergh L.I.V. et al, 2017). Lack of rest time, poor supervision, inadequate salary standards, leave schedule arrangements that are often unclear, and career issues and promotions that have unclear rules (Susilowati I.H et al, 2013).

Work stress, conflict between work and personal life, pressure from superiors or colleagues, lack of social support at work, side jobs, and travel time to work. (Dahlan A., Baiduri W 2022). Disturbances originating from family problems, social interactions, and economic burdens influence fatigue. (HSE UK, 2006 & 2018)

The relationship between individual factors and fatigue

Individual factors that cause fatigue and health problems are socio-demographic factors which consist of demographic factors (gender, age, education, domicile), work factors (work environment, work schedule, employment status, and length of work), socio-economic and standard of living (housing conditions, travel time, salary, dependents, forest installments) and lifestyle (nutrition, smoking, drinking alcohol, exercise and sleep quality). (Pelders, J., & Nelson, G. 2018). There is an association of unhealthy lifestyle behaviors such as smoking, alcohol consumption, and being overweight with the risk of fatigue (Yeboah B., et al, 2021)

Fatigue prevention management

A Fatigue Risk Management System (FRMS) is an important part of fatigue prevention management. FRMS uses prevention strategies from the company and worker levels. These include changing work schedules, training employees on managing fatigue, and integrating health, safety, and well-being strategies into management systems and broader business plans. (IPIECA-IOGP, 2019).

The impact caused by fatigue can be minimized by controlling the risk factors by workers for themselves and the organization in the management system, especially fatigue management. Fatigue risk control can be carried out at the prevention and mitigation stages. At the prevention stage, it is carried out against the possibility (likelihood) of long working hours, night/shift work, poor worker health, prevention of workers who are unfit to work, and unreasonable work contracts, while control is at the mitigation stage carried out when fatigue is known. (Kurniawidjaja, 2019)

CONCLUSION

Risk factors for fatigue in offshore oil and gas workers are environmental factors, work factors, psychosocial factors, and individual factors. A fatigue risk management system is needed for prevention and control efforts that involve workers for themselves and the organization in the fatigue management system.

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