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Determinants of Occupational Fatigue and Work Accident History in Mechanical Heavy Equipment Workers at PT X site PT Z Samarinda

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Abstract

Background: *Work fatigue is critical issue that needs to be addressed properly because it can lead to various problems such as loss of efficiency at work, decreased productivity and work capacity and has the potential to cause work accidents. The factors that cause fatigue vary widely, including awkward work postures, work periods, and hot work climates. Several cases of work accidents have occurred at PT X which are suspected to be due to work fatigue. This study aims to determine the relationship between work period, work posture and work climate with work fatigue and analyze the relationship with work accident history.*

Method: *A quantitative cross-sectional design study was conducted on 67 respondents (total sampling). The measuring instruments used consisted of questionnaires and QUESTemp 36 Heat Stress Monitor. Data were analyzed using the Spearman Rank test.*

Result: *A total 86.6% of participants experienced mild work fatigue and 41.8% of participants had experienced work accidents. Spearman Rank test showed work periods (p = 0.022), work postures (p = 0.021) were significantly related to work fatigue. Work climate (p = 0.139) was not related to work fatigue. Work fatigue (p=0.0004) was significantly related to work accident history.*

Conclusion: *Work periods and posture were significantly related to work fatigue. Work fatigue was related to work accidents. Control efforts are needed to reduce/overcome work fatigue experienced by workers (such as provide training on proper work posture and reducing workload) so that it does not trigger work accidents work fatigue does not occur.*

Keywords*: Work accidents, Work climate, Work fatigue, Work period, Work posture*

INTRODUCTION

An accident is an event or event or occurrence that is unplanned, unexpected expected, and unexpected by us humans that occur without an element of intentionally and the adverse effects experienced as a result of the accident. In the workplace there is also the potential for accidents and this is commonly called work accidents.[1] According to 2022 data from the International Labor Organization (ILO), over 250 million workplace accidents occurred, more than 160 million workers suffered from work-related illnesses, and 1.2 million lost their lives due to occupational accidents and diseases.[2] Global figures also show that 360 million workers suffered non-fatal work injuries in 2016, while 5.4 % of global Gross Domestic Product (GDP) is lost annually due to workplace accident.[3]

Workplace accidents have become more prevalent in the last five years, the trend of claims for accident insurance (Jaminan Kecelakaan Kerja (JKK)-Ind) and death insurance (Jaminan Kematian (JKM)-Ind) on average continue to experience an increase. Based on Social Security Agency (Badan Penyelenggara Jaminan Sosial-Ind) data Employment, the number of JKK claims in 2019 recorded 182,835 cases. Then the number of claims in 2020 were recorded at 221,740 cases and 234,370 claims in 2021. Number of claims increased again in the year 2022 to 297,725 claims. In the period January to November 2023 the number of accidents that filed JKK claims reached 360,635 cases with the most cases in the company and in plantations. An increase also occurred in the number of JKM claims. In

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2019 the number of MFI claims reached 31,324 cases, in 2020 the number of claims reached 32,094 claims, in 2021 the number of claims reached 104,769 and in 2022 experienced an increase to 103,349 claims. In the period January to November 2023 the number of claims jumped to 121,531 cases.

One of the causes of work accidents is fatigue.[4,5,6] Occupational fatigue is a significant issue that must be managed appropriately, as it can lead to a range of problems, including reduced work efficiency, lower productivity and performance, and negative impacts on health and physical resilience, all of which increase the risk of workplace accidents.[7] According to the New Zealand Government WorkSafe data, workplace fatigue was found to be common, with 20% to 40% of workers reporting significant fatigue at any given time.[8] Factors that cause fatigue vary greatly, including awkward work postures, length of service, and hot work climate. This is evidenced by the results of research conducted by Hijah showed that most respondents who worked as welding workshop workers had work postures with a high risk of experiencing severe fatigue as much as 40%. In addition to work posture, work accidents can also be influenced by length of service. A positive effect arises when workers gain more experience and skill the longer they perform a job. On the other hand, an adverse impact can occur when prolonged job duration leads to increased fatigue, boredom, and engagement in monotonous, repetitive tasks. In addition to tenure, work fatigue can also be influenced by the work climate.[9] According to Sunaryo, if workers are exposed to working climate conditions with hot temperatures that exceed the permissible Threshold Value (TLV), it can cause occupational diseases or work accidents.[10]

PT X is a company engaged in coal mining contractor, rental and transportation of heavy equipment located in Balikpapan city, East Kalimantan, Indonesia East, Indonesia and has a branch office in the city of Samarinda. The results of a preliminary study showed that there had been several work accidents, most of which occurred in the repair and maintenance department. This study aims to determine the factors related to work fatigue in workers at PT X and analyze its relationship with work accident history.

METHOD

Participants and Study Design

This quantitative study used a cross-sectional design and was conducted at the PT X site of PT Z in Samarinda City. The study took place from September to October 2024, involving a population of 67 heavy equipment mechanics from the repair and maintenance department.

Measurements and Procedure

The sampling technique used was total sampling. The instruments used were the Work Fatigue Feeling Questionnaire (KAUPK2), work injury questionnaire, Quick Exposure Check (QEC) questionnaire and QUESTemp 36 Heat Stress Meter. Data analysis used the Rank Spearman test.

Statistical Analysis and Ethical Clearance

Data analysis used the Rank Spearman test. This research received ethical approval, ethics number 710/UN17.11/DT/2024, from the Health Research Ethics Committee of the Faculty of Public Health, Mulawarman University.

RESULT

Table 1 shows the characteristics of respondents. Most respondents (37.3%) were 23-34 years old, 100% male, most (83.6%) were married, most (64.2%) had 8-20 years of work experience, and most (71.6%) were vocational school graduates. In table 2, it is known that Most respondents (58.2%) have never experienced a work accident, but 41.8% of respondents have experienced a work accident (rarely and often). Most respondents (86.6%) experience mild work fatigue. Most respondents' work postures (41.8%) are at medium risk and (44.8%) experience awkward work postures, and most respondents (73.1%) work in a medium category work climate.

The results of the Cramers Phi test show age not significantly related to work fatigue. Spearman Rank test show that work period (α=0.022) and work posture (α=0.021) are significantly related to work fatigue experienced by workers. Work fatigue experienced by workers is significantly related to a history of work accidents (α=0.004) (Table 3).

Table 1. Characteristics of Heavy Equipment Mechanic Worker at PT X (N=67)

Characteristics	Category	Σ	%
Age	24-34	25	37,3
	35-45	17	25,4
	46-56	14	20,9
	57-63	11	16,4
Gender	Male	67	100
	Female	-	-
Marital Status	Married	56	83,6
	Not Married	11	16,4
Working Period	Medium (8-20 years)	43	64,2
	Long (21-33 years)	24	35,8
Education	Not Graduated	-	-
	Elementary School	2	3
	Junior High School	4	6
	Senior High School	13	19,4
	Vocational School	48	71,6

Table 2. Frequency Distribution of Research Variables of Heavy Equipment Mechanic Workers at PT X (N=67)

Variable	Category	Σ	%
Work Accidents	Never	39	58,2
	Rarely	24	35,8
	Often	4	6
Work Fatigue	Light	58	86,6
	Moderate	8	11,9
	Heavy	1	1,5
Work Posture	Normal	9	13,4
	Medium	28	41,8
	Awkward	30	44,8
Work Climate	Light	13	19,4
	Medium	49	73,1
	High	5	7,5

Table 3. Bivariate Analysis Results (N=67)

Variable Relationship	*Spearman Rank*	
	α	*r*
Age_Work Fatigue**	0,880	0,092
Length of Service_Work Fatigue	0,022*	-0,279
Work Posture_Work Fatigue	0,021*	0,281
Work Climate_Work Fatigue	0,139	0,183
Work Fatigue_Work Injury	0,004*	0,350
*significant; ** Cramer's V test		

The characteristics of work at PT X include moderate workload with hourly working hours of 75%-100%, based on the results of measuring the work climate with the wet bulb temperature index (WBTI) indicator, the results were 27.8^{0}C (Table 5). When compared to the Threshold Limit Value (TLV) for work climate under the moderate workload category and 75%–100% hourly work duration, as stated in Table 4 and based on the Regulation of the Minister of Manpower of the Republic of Indonesia No. 5 of 2018 concerning Occupational Safety and Health in the Work Environment, it can be concluded that the work climate remains within the normal range.

Table 4. Permissible Threshold Value of Working Climate Index of Wet and Ball Temperature (ISBB)

Hourly Work Timing	ISBB (°C) Workload			
	Light	Moderate	Heavy	Very Heavy
75% - 100%	31,0	28,0	-	-
50% - 75%	31,0	29,0	27,5	-
25% - 50%	32,0	30,0	29,0	28,0
0% - 25%	32,5	31,5	30,5	30,0

Table 5. Results of Company Work Climate Measurement

Measurement Point/Area	Metabolic Rate/Workload	Working Time Arrangement	Temp. (°C)	RH (%)	ISBB (°C)		
					Measurable	Uncertainty	TLV*
Workshop	Medium	75% - 100%	27,8	81,6	26,1	0,5	28,0

DISCUSSION

Respondent Characteristics

Based on the results of the study, the majority of respondents' ages were in the age range of 24-32 years and 33-40 years. The results of the crosstab analysis using the Chi-Square test showed that (p value 0.88> 0.05) which means that there is no relationship between age category and job fatigue in heavy equipment mechanic workers. The results of this test contradict research conducted by Syuqinah which states that there is a relationship between age and job fatigue in technical service workers of PT PLN (Persero) Customer Service Unit Tanjung in 2020 with the results of the chi square statistical test obtained p value = 0.000 <0.05.[11]

Age is one of the factors that cause fatigue at work, this can occur because as workers get older, their muscle strength will decrease and can cause workers to feel tired quickly when working. This can occur because the physical capacity of work such as vision, hearing, and reaction speed tends to decrease because with age this can affect a person's work productivity.[12] However, in this study no relationship was found between age and fatigue (p=0.88), this is most likely due to the fact that most of the respondents were still in the young category.

Based on the results of the study, the majority of respondents' marital status is married. The results of the crosstab analysis using the Chi-Square test showed that (p=0.055 > 0.05) which means that there is no relationship between the marital status category and job fatigue in heavy equipment mechanical workers. This result contradicts Agustin who stated that there was a significant relationship between marital status in workers at PT Adhi Persada Gedung Bekasi with (p=0.000 <0.05).[13]

Relationship between Working Period and Fatigue in Heavy Equipment Mechanic Workers PT X

The results of research conducted on heavy equipment mechanic workers regarding the relationship between work period variables and job fatigue have a significant relationship. The working period can be said to have a positive effect on a person when viewed based on the work experience that has been obtained. The longer the working period, the worker will have more experience in doing his job. The length of service can also be said to have a negative effect on a person when viewed based on the length of time workers interact with the hazards posed either based on their work or the work environment. The longer the working period, the higher the level of risk of exposure to hazards posed both based on work and the environment.[14] A long working period and carried out continuously can cause a negative impact in the form of a limit to the body's resistance to the work process which can lead to the onset of fatigue, this can occur because a person's work experience will affect the occurrence of fatigue. The longer a person works in a company, it will affect the level of fatigue he experiences.[15]

Based on the results of research that has been carried out using the Spearman Rank test, it is known that there is a relationship between the length of service with job fatigue experienced by heavy equipment mechanic workers PT X. Data analysis on the work period variable can be seen that the majority of workers experience mild fatigue. Based on the correlation results, it shows that the longer

the working period of workers, the more workers are exposed to the implementation of occupational health and safety, so that workers' behaviour towards occupational fatigue decreases.

Based on the distribution of the working period and the level of fatigue in heavy equipment mechanic workers, it can be seen that the majority of heavy equipment mechanic workers experience a medium working period with a mild level of fatigue, this can occur because heavy equipment mechanic workers with a medium or new working period have a younger age so that the work demands given are heavier, and do not yet have experience in regulating the level of fatigue at work, while workers who work with a long working period have an older age so that work demands are lighter, and have the experience to be able to regulate or control the level of fatigue because they have experience regarding the work done if they have felt symptoms of fatigue. The implication of this study is that if work fatigue that increases along with the new working period is to be reduced, then work skills need to be improved and training needs to be provided so that workers can organize effective work patterns with minimal fatigue levels.

Relationship between Work Posture and Occupational Fatigue in Mechanical Workers of Heavy Equipment PT X

The results of research conducted on heavy equipment mechanic workers regarding the relationship between work posture variables and work fatigue have a significant relationship. Work posture is an important factor in evaluating the effectiveness of a job. Workers can achieve superior results if workers apply good work postures. Conversely, if the work posture is not good, workers feel tired more quickly. Static work postures have a high risk of causing health problems. A person who works in a static work position will experience a decrease in blood flow to the muscles, then the ability of the muscles is hampered to receive a supply of glucose and oxygen. Energy reserves are then used by the muscles, so that the rest of the body's metabolism cannot be removed efficiently. As a result, muscles that work statically will experience painful sensations and feel tired quickly.[16]

Repetitive movements performed by workers, arms/wrists no more than 10 repetitions per minute, upper arms/elbows no more than 10 repetitions per minute and repetitive movements performed in awkward working positions can cause fatigue, and ultimately pain and discomfort.[17] This is in line with research conducted by researchers where there are still many workers who do repetitive work performed. Heavy equipment mechanic workers complained of occupational fatigue health problems such as difficulty thinking, tired of talking, tend to forget things, and reluctance to look at people, which are signs of workers experiencing occupational fatigue. The worker also complained that the worker felt tired all over. The worker also stated that they work with repetitive movements that are done very often or always move when repairing heavy equipment.

Based on the results of research that has been conducted using the Spearman Rank test, it is known that there is a relationship between work posture and work fatigue experienced by heavy equipment mechanic workers PT X. Data analysis on work posture variables can be seen that the majority of workers experience awkward work postures. According to Latief, the attitude or position of the body when doing work is a description of the position of the body, head and other limbs, work attitudes with unhealthy or awkward work systems can cause fatigue.[18]

Work posture is a significant factor contributing to occupational fatigue, as it represents the physical positioning of the body during task performance. Inappropriate or ergonomically unsound postures can increase physical strain, elevating the overall workload and reducing a worker’s ability to perform efficiently. Work postures are generally categorized into sitting, standing, bending, and dynamic postures, each of which can influence fatigue levels depending on duration and task demands.[19]

The implication of this research is that to avoid work fatigue due to awkward postures, the company must improve work postures, by providing training on occupational health and safety regarding good work postures and the company can also provide work posture assessments that must be carried out periodically and structured every 3 months, this aims to determine the cause of the risk of injury and improvements can be made.

Relationship between Work Climate and Occupational Fatigue in Heavy Equipment Mechanic Workers PT X

The results of research conducted on heavy equipment mechanic workers regarding the relationship between work climate variables and work fatigue do not have a significant relationship. Work climate refers to the combined effect of environmental factors, such as temperature, humidity, air movement, and radiant heat, on the body's heat dissipation during physical activity. An uncomfortable work climate can negatively impact a worker's physiological state, potentially causing elevated body temperature, increased blood pressure, and excessive perspiration.[20] Workers who work in a work environment that is not in accordance with the TLV standard tend to have higher fatigue levels.[21]

The hot working climate causes the body temperature to increase so that the process of excessive sweat output can cause the body to dehydrate and lack of fluids and sodium salts, so that the body will quickly experience fatigue. Changes in climate/weather in the workplace environment have caused heat stress that will be accepted by the workforce working in the workplace environment as an additional heat load (in addition to the heat load generated by the body as a result of work performance), which can result in many negative effects on labour both in the form of work disruption (work performance) and health problems.[22] Based on the results of research that has been conducted using the Spearman Rank test, it is known that there is no relationship between work climate and job fatigue experienced by heavy equipment mechanic workers PT X. Data analysis on work climate variables can be seen that the majority of workers work with a moderate work climate.

Based on the results of research that has been carried out with the results of the company's work climate measurement test carried out at 4 points, namely in the workshop, PIT A, PIT B, and PIT C, the results of workers' time at work fall into the 75% - 100% category, this is because workers are in the workshop or mining area for 10 hours including during breaks (1 hour) or can be said to be 75% - 100% of working time, so that workers are not exposed to high heat stress, workers are only allowed to be in the moderate workload category, The medium workload in question is the existence of lifting and transporting work activities but not in the heavy category, and the maximum temperature that can be accepted by workers with working time in the 75% - 100% category and moderate workload according to Permenaker number 5 of 2018 is at 28 ° C, while based on measurements taken by the Occupational Safety and Health Center, the temperature measurement results in the workplace are 27.8 ° C. It can be concluded that the work climate in the company environment has met the TLV with the provisions of the workload of workers in the medium category, these results can be concluded that there is no significant relationship between the work climate and fatigue at PT X because based on the measurements of the work climate carried out, the work climate at PT X is still included in the TLV.

Relationship between Work Fatigue and Work Accident History in Heavy Equipment Mechanic Workers PT X

The results of research conducted on heavy equipment mechanic workers regarding the relationship between work fatigue variables and work accident history have a significant relationship. Work fatigue can cause a decrease in worker productivity in completing a job. Work fatigue can also potentially cause work accidents. In addition, fatigue can reduce self-control in terms of work safety so that it causes errors in work that can lead to work accidents.[23]

The majority of work accidents that occur in companies are in the near miss and incident categories, not in the accident or fatality categories. The history of accidents in the near miss category that occurred in the company was a worker being scratched while repairing heavy equipment and the history of work accidents in the incident category that occurred in the company was a worker's hand being caught when installing a camber, resulting in an injury to the worker's hand. The fatigue felt by workers will have an impact on worker productivity, causing various potential risks of danger because workers are not focused on doing their work. Fatigue is part of the human factor which is one of the basic causes of unsafe work behaviour. Based on the theory of work accidents, work accidents can occur due to unsafe work behaviour and unsafe working conditions.[24]

Based on the results of the study that has been conducted using the Spearman Rank test, it is known that there is a relationship between work fatigue experienced by workers and a history of work accidents experienced by heavy equipment mechanic workers of PT X. Data analysis on the work fatigue variable shows that the majority of workers experience mild work fatigue. Work accidents that

have occurred are included in the category of near miss and incident work accidents, not in the category of accidents or fatalities. This study is in line with research conducted by Charisma, on the relationship between work fatigue and the occurrence of work accidents at PT. Putra Karangetang, Popontolen Village, South Minahasa Regency, shows a relationship between work fatigue and the occurrence of work accidents, it is known that the significance value of work fatigue = 0.000 <0.05, the results can be concluded that there is a significant relationship between work fatigue and the occurrence of work accidents at PT Putra Karangetang.[25]

The implication of this study is to avoid work fatigue that results in work accidents, companies must conduct fatigue checks using a routine examination matrix to ensure that workers who will work are truly ready and are not experiencing fatigue, increase knowledge and skills in carrying out activities related to mechanical work, be more careful when doing work, and training needs to be provided for mechanical workers. This research has advantages, including analyzing the relationship between work fatigue and work accidents by considering work environment factors (work climate) with using objective measurement tools, but has limitations in measuring work fatigue (only measuring physical work fatigue).

CONCLUSION

It was known that 39 respondents (58.2%) had never experienced a work accident, 24 respondents (35.8%) rarely experienced a work accident, and four respondents (6%) often experienced a work accident. There was a relationship between work period (p = 0.022) and work posture (p = 0.021) with work fatigue in heavy equipment mechanic workers at PT X. There was no relationship between work climate and work fatigue in heavy equipment mechanic workers at PT X (p = 0.139). There was a relationship between work fatigue and a history of work accidents in heavy equipment mechanic workers at PT X (p = 0.0004).

To minimize work fatigue experienced, companies are advised to improve work skills so that workers can organize effective work patterns, and regulate work rhythms according to applicable regulations. Companies are also advised to improve work postures by improving the design of work places and tools, conducting routine work fatigue checks based on the planned Health, Safety, and Environment (HSE) work program, and improving occupational health and safety knowledge and work skills so that they can work safely and securely.

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