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Unlocking the Hidden Impact: How Mental Workload Shapes Safety-Insights from NOSACQ-50 and NASA-TLX Method

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ABSTRACT
The decrease in capability is caused by work fatigue and the level of error in work will increase. The increase in errors in work will cause the opportunity for work accidents in the industry which is the cause and effect of a work accident. This study aimed to determine solutions to eliminate mental workload from a safety climate based on NOSACQ-50 using the NASA-TLX method at PT. X part of The Batam City field in 2021. This quantitative study uses an analytical design with a cross-sectional approach between NOSACQ-50 to determine safety climate and NASA-TLX Method to determine mental workload based on the safety climate. The objects of this research are all workers of PT. X in 2021, with a sample size of 30 respondents. Statistical analysis used chi-square test. The results of this study show that Mental Workload in PT.X mostly was in moderate Level (73,3%) with the highest workload score was in the physical needs. NASA-TLX shows that Empowerment of Work Safety from Management was the significant factor causing mental stress. It was concluded that mental stress is caused by poor work arrangements. Suggestions for companies is to rotate work in each group of workers, especially riggers so that the workload is evenly distributed, and top management participates and is committed to carrying out OHS programs by directly demonstrating the programs that have been set.

INTRODUCTION

The safety climate is critical to establish a safe working environment. The safety climate is defined as a concept perceived or determined by workers' perceptions of the importance of safety and how occupational safety, management, and occupational health are prevalent in the workplace at a given period.[1,2] A positive security climate indicates that a group of workers understands the importance of workplace safety and prioritizes it when considering the security climate.[3–5]

NOSACQ-50 (The Nordic Safety Climate Questionnaire) is a method for determining the occupational safety climate developed by Team Nordic (Sweden, Finland, Denmark, Norway, and Iceland). NOSACQ-50 has seven dimensions, namely management's work safety priorities, management that develops work safety, proper management of work safety, employees who are committed to working safely, employees who prioritize work safety, and attitudes that do not want to take risks to work safety, communication, and job safety training, including trusting in the work safety competence of colleagues, worker confidence in the safety system.[6,7]

PT. X (PT; refers to a company or corporation in Indonesia, X; was used because the company doesn't want their name to be exposed or publicized) is engaged in loading and unloading service providers, which carry out stevedoring, cargo during, forwarding, lifting and handling, supply chain, and service, with stages of transportation work to the dock. Then goods are loaded onto PT. X ships.[8] The PT. X has never measured the safety climate and mental workload, it is not an obligation to measure the safety climate using NOSACQ-50 and measure mental workload using the NASA-TLX method, but it can be helpful to be input and evaluation for companies regarding workers' commitment and perception of safety.[9]

Based on the results of initial observations that researchers made at PT.X, workload, especially physical demand, is very high for the physical needs in question, such as pulling when installing webbing slings to pipes, pushing, and twisting. One of the factors in the occurrence of unsafe behavior is due to fatigue.[10,11] The decline in capability caused by work fatigue and the level of errors in work will increase.[12] Increased employment errors will allow for work accidents in the industry.[13] This is the cause of a work accident. These physical needs are included in the NASA-TLX (Task Load Index) mental workload consisting of 6 dimensions: cognitive demand, physical demand, temporal demand, effort, and frustration.[14–16]

NASA-TLX is one of the modes for mental workload measurement, developed by Sandra G. Hart of NASA-Ames Research Center and Lowell E. Staveland of San Jose State University in 1981. This method has a compact measuring scale and does not require much cost or time.[14]

Unveiling the concealed impact of mental workload on safety is paramount to create a secure work environment. This study aims to investigate the intricate relationship between mental workload and safety by utilizing the NOSACQ-50 and NASA-TLX methodologies. By delving into the findings, the study seeks to shed light on the factors contributing to mental workload and propose effective strategies for enhancing safety and performance. The research will focus on uncovering these insights at PT. X Batam city field section in 2021, facilitating actionable recommendations for improved safety measures.

MATERIAL AND METHOD

This research was quantitative research which designed as observational research with a cross-sectional approach to determine the relationship between mental workload as a dependent variable and the occupational safety climate measured by the NOSACQ-50. This study's population is the entire PT.X field section in 2021, with a sample size of 30 respondents determined by total sampling. The occupational safety climate data collection instrument used a questionnaire (NOSACQ-50) with a Likert scale using positive questions on a scale of 1-4 and vice versa for negative questions; at the same time, collecting mental workload measurement data using the NASA-TLX method using a score of 0-100. The data was analyzed using statistical tests using the chi-square method with the confidence interval used at 95% or $\alpha = 0.05$ to determine the correlation of the variables.

The ethical clearance process was conducted before conducting this research. The ethical clearance was obtained from the Research Ethics Committee of Faculty of Health Science Lamongan Islamic University on October 28,

2022. The ethical clearance number for this research was 120/13.251/KEPK/2022. The participants of this study were informed about the purpose and benefits of the study, and their consent was obtained before data collection. The participants were also informed about their right to withdraw from the study at any time without any negative consequences. Confidentiality of the participants was ensured by not disclosing their identity and keeping their data secured. The researchers also followed the ethical guidelines of the Helsinki Declaration (2013) and Good Clinical Practice guidelines (GCP) to ensure the ethical standards of the research were met.

RESULTS

The safety climate is measured using the NOSACQ-50 method in PT. X field division in 2021, as many as 30 respondents in seven dimensions. Where the score uses the average score range of <2.70 (Very Low); 2.70-2.99 (Low Enough); 3.00-3.30 (Good Enough); and >3.30 (Good). At the same time, the measurement of mental workload in the same respondents was carried out with the NASA-TLX method using an average score range of >80 (Heavy Workload); 50-79 (Medium Workload); and <50 (Light Workload). The result describes the workload score compared to the NASA-TLX Standardized indicators comprising 6 indicators ranging from 0-100%.

Based on Table 1, the classification of medium mental workload got the highest score, with 22 (73.3%); for the type of heavy mental workload it was the second-highest score at 5 (16.7%). Then, in the comparison between NASA-TLX elements in Table 2, it can be seen that the six aspects of NASA-TLX, namely mental needs (Mental Demand), physical needs (Physical Demand), time needs (Temporal Demand), performance (Performance), effort level (Effort), and frustration level (Frustration Level). The highest number of scores is physical needs (Physical Demand) with 9.110.

The relationship of the safety climate with mental workload and statistical tests (Table 3) can be presented that ρ-value (ρ-value <0.05) dimension one safety climate with the mental workload, i.e., 0.021; dimension two safety climate with the mental workload is 0.000; measurement three safety climate with the mental workload, i.e., 0.005; dimension four safety climate with the mental workload, i.e., 0.010; dimension five climate safety with a mental workload of 0.027; dimension six safety climate with the mental workload of 0.019; The 7th dimension of the safety climate with a mental workload is 0.002, which means that there is a relationship in each of the seven dimensions of the safety climate with the mental workload.

Table 1. Workload Frequency Distribution

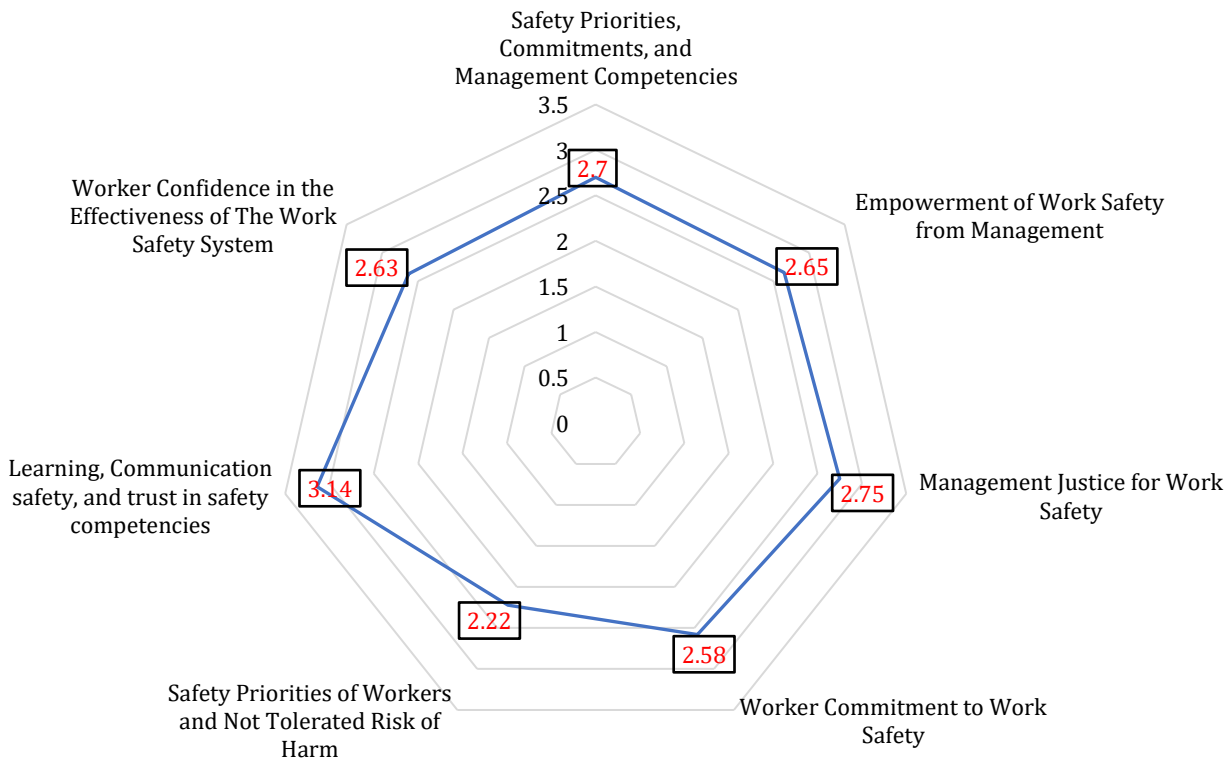
Workload Classification	n = 30	%
Heavy Workload (>80)	5	16.7
Medium Workload (50-79)	22	73.3
Light Workload (<50)	3	10

Source: Primary Data, 2021

Table 2. Workload Score Calculation Results with NASA-TLX Indicator

Indicators	Scores 28.150	Average 938.33	%
Mental Needs	4.370	145.67	15.52
Physical Needs	9.110	303.67	32.36
Time Requirements	2.790	93	9.91
Performance	3.540	118	12.58
Effort	770	256.67	27.35
Frustration Level	640	21.33	2.27

Source: Primary Data, 2021



Source: Primary Data, 2021

Table 3. Safety Climate Correlation Analysis Based on NOSACQ-50 with Mental Workload Using NASA-TLX Method

NOSACQ-50 Dimensions	*p*-value (Vs. Workload)	Significance
Safety Priorities, Commitments, and Management Competencies	0.021	Significant
Empowerment of Work Safety from Management	0.000	Significant
Management Justice for Work Safety	0.005	Significant
Worker Commitment to Work Safety	0.010	Significant
Safety Priorities of Workers and Not Tolerated Risk of Harm	0.027	Significant
Learning, Communication safety, and trust in safety competencies	0.019	Significant
Worker Confidence in the Effectiveness of The Work Safety System	0.002	Significant

Source: Primary Data, 2021

DISCUSSION

Figure 1 shows us that the highest score is in the sixth dimension, with an average of 3.14, an aspect of learning, safety communication, and trust in safety competencies. The sixth talks about the perception of workers about safety in the workplace in terms of discussing safety issues, learning from work experience, helping each other to work safely, receiving input regarding protection well, and believing in each other's ability to ensure safety while working.[17] A high score on dimensions includes learning, safety communication, and trust in the safety competencies in PT. X shows that all field personnel support implementing OHS (Occupational Safety and Health) to participate in the company's OH&S management system (Occupational Safety and Health) in terms of safety communication. As for the state of safety, communication is carried out by PT. X includes toolbox meetings, HIRADC (Hazzard Risk Assessment and Determining Control), JSA (Job Safety Analysis), program socialization and OHS policy, OHS training, and following up on OHS findings. A study revealed that safety

communication significantly influences work safety. [18]

The lowest value is in dimension 5, with an average of 2.22; dimension 5 is an aspect of the safety priority of workers and the non-tolerance of the risk of harm. Dimension 5 explains workers' perception of work safety regarding whether they generally prioritize safety over job targets, do not accept risky conditions, or do not take and do not show courage contrary to safety aspects.[17,19]

Based on Table 1, the classification of moderate mental workload got the highest score, with 22 (73.3%); for the type of heavy mental workload, the second-highest score is 5 (16.7%). The number of physical needs is very high, making workers exhausted. According to Nurmianto, work fatigue can lead to decreased capacity and increased errors in work, thus allowing work accidents in the industry.[20] If physical needs are high and cause fatigue, this can reduce productivity. Budiono said a relationship exists between fatigue and a company's productivity.[21]

As the results shown on data on Table 3, it can be assumed that the workers did not put safety first or a priority, and the company is still less committed. Adu, M. A. informs that safe behavior at work (safety behavior) can be predicted by the climate of work safety (safety climate).[22] Nopiyanti et al's Research, also shows that the safety climate figure is quite good with a value of 2.02-3.07 and an excellent OHS culture with a value of 671.[23] In the same research indicates that commitment is one of the main factors of the work safety culture; without support from the management, it is tough to achieve success in carrying out work safety programs. Kurnia stated that commitment to the company is an essential behavioral dimension and can be used to assess workers' attachment to the company.[24] This matter was supported which revealed that the level of an employee's willingness to prove himself to the company and his willingness to contribute to the company activity is a commitment to the company.

The results of the study show that workers at PT. X prioritize learning, safety communication, and trust in safety competencies in the workplace, but they do not prioritize safety as much as they should. This finding is consistent with previous research that suggests that safety communication significantly influences work safety.[25] It is essential for companies to have a good safety climate to ensure safe behavior at work.[22] However, the study indicates that the company is still less committed to work safety programs.[26]

Furthermore, the study found that the workers' mental workload was mostly classified as moderate, and the physical needs of workers were high, leading to fatigue that can decrease their capacity and increase errors in work, which can result in work accidents.[27] This finding is consistent with the previous research that suggests that there is a relationship between fatigue and a company's productivity.[28]

Commitment to the company is also an important behavioral dimension that can be used to assess workers' attachment to the company.[29] The level of an employee's willingness to contribute to the company's activity is a commitment to the company.[30] Therefore, it is essential for companies to support work safety programs and have a good safety climate to achieve success in carrying out work safety programs.

In conclusion, the study emphasizes the importance of prioritizing safety in the workplace, improving safety communication, and promoting a good safety climate. Companies should also consider reducing workers' mental workload and physical needs to prevent fatigue and increase productivity. Finally, companies should strive to increase workers' commitment to the company and work safety programs.

The findings presented in the chart and tables highlight several crucial aspects of safety culture in PT. X. The high score in the sixth dimension of safety culture suggests that workers perceive safety as an essential aspect of their job and are committed to learning and improving safety practices. This is a positive sign as it indicates that the workers are willing to engage in safety-related activities, such as training and reporting safety concerns, which can help reduce the risk of accidents and injuries.

However, the low score in the fifth dimension suggests that workers may not always prioritize safety over job targets and may be willing to take risks. This could lead to unsafe behavior and potentially increase the risk of accidents and

injuries. It is essential to address this issue and promote a safety-first culture where workers prioritize safety over job targets.

The high mental workload and physical needs of workers also raise concerns about safety. Fatigue and decreased capacity can increase the risk of errors and accidents. It is crucial to manage workload and provide adequate rest to ensure that workers are on alert and focused while on the job.

The safety climate in PT. X appears to be good, but the commitment of the company to safety still needs improvement. Management support and commitment are crucial factors in promoting safety culture, and without it, safety programs may not be successful. Companies must invest in safety culture and provide the necessary resources to ensure that workers are equipped to prioritize safety and engage in safety-related activities.

In conclusion, safety culture is a critical aspect of any organization, and PT. X must take steps to address the areas of concern identified in the result chart and tables. By prioritizing safety, managing workload, and providing adequate support and resources, PT. X can create a safe and healthy work environment for its workers.

Therefore, it can be concluded that although workers in PT. X support the implementation of OHS in the company and show good safety communication, there is still a need to improve their perception of safety priority and risk tolerance. The study suggests that the company should prioritize safety and provide adequate training and support to workers to enhance their safety awareness and risk management skills.

Another research gap identified in this study is the issue of mental workload and physical needs. The study shows that workers in PT. X experience high levels of physical needs, leading to fatigue and reduced productivity, which can increase the risk of work accidents. However, the study also indicates that workers experience moderate mental workload more frequently than heavy mental workload, which suggests that there may be room for improvement in managing mental workload to reduce fatigue and improve productivity. Future research can explore ways to optimize mental workload management in the construction industry to enhance workers' safety and well-being.

In terms of practical implications, this study highlights the importance of safety communication, trust, and learning in promoting work safety. The study suggests that companies should prioritize safety communication and create a culture of trust and learning to improve workers' safety awareness and risk management skills. Moreover, the study emphasizes the need for companies to prioritize workers' physical needs and mental workload management to enhance their well-being and productivity, which can ultimately contribute to improving work safety.

Overall, this study provides valuable insights into the perception of work safety in the construction industry in Batam and highlights some important research gaps and practical implications that can inform future research and practice in enhancing work safety and well-being in this industry.

CONCLUSION AND RECOMMENDATION

The majority of field workers at PT. X has a medium workload. The work climate based on worker perceptions measured by NOSACQ-50 shows the working environment in PT. X is likelier to learn, communication safety, and trust in competence is indicated by the highest perception average of 3.14. Mental workloads with the NASA-TLX method significantly correlate with all dimensions of occupational safety climate measurements. Recommendation for workers to make the most of rest time to be reinvigorated when returning to work. Wear PPE (Personal Protective Equipment) completely while working, such as helmet, gloves (for rigger work), and safety shoes. The company can rotate each group of field workers, especially the loading and unloading rigger workforce, so that the workload can be divided equally.

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AUTHOR CONTRIBUTIONS

RS is the main researcher who has research ideas and concepts, formulates research methodologies, conducts data analysis and

drafts articles, MG as the second author helps conduct data analysis and make research reports and translate articles into English. Meanwhile, N and NU as the third and fourth authors contributed as data collectors in the field and made field observations. Finally, RH as the fifth author facilitate the administration process to conduct the research on PT. X.

CONFLICTS OF INTEREST

The authors declare no conflict of interest.

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