PLS Model for the Influence of Work Environment and Behavior on the Health and Performance of Ship Crews

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Abstract. Based on Blum's theory, the environment and behavior can affect human health. The World Health Organization (WHO) places risk factors in the work environment as the tenth leading cause of illness and death. Occupational illness is a condition caused by workplace exposure caused by physical, chemical, biological, ergonomic and psycho-spatial factors in the work environment to the extent that normal physiological mechanisms are affected and workers' health is impaired. The behavior of using personal protective equipment can protect workers from exposure to these factors. A safe and danger free work environment can affect health to make the crews excited and work well which will contribute to the productivity and performance. Internationally, the marine fisheries sector is recognized as the most dangerous workplace in the world and is higher significantly as the cause of occupational illness and accidents comparing with the other sectors such as agriculture and construction. Fishers can deal with physical such as vibration, noise, temperature, chemical, biological, ergonomic and psychosocial hazards when they are doing the duties and responsibilities that can affect their health and performance. Based on that, a model of the effect of work environment and behavior on the health and performance of the crew has been designed. The method used to analyze the relationship between variables and evaluate the goodness of fit the designed model is partial least square. Data obtained from questionnaires that have been filled out by 125 crews of pole and line fishing vessels as respondents. The analysis shows that all indicators of each variable are valid and reliable which means that each indicator of each variable is able to measure each variable well based on a value of composite reliability ≥ 0.6 and a Croncbach alpha value of ≥ 0.7 and a value of AVE ≥ 0.5 for the reflective variable and the value of T- statistics of each indicator > 1.96 and P-value < 0.05 for formative variables. Evaluation of the goodness of fit the model based on Q^2 value or predictive-relevance, the analysis shows the Q^2 value of 0.826 almost 1 thus make model for the influence of the work environment and behavior on the health and performance of ship crews is worth mentioning very well. The study aims to design a model of the effect of the work environment and behavior of the use of personal protective equipment on the health and performance of fishermen on pole and line fishing vessels using Partial Least Square (PLS) analysis.

Keyword: Work Environment, Behavior, Health, Performance, PLS and Ship Crew of Pole or Line Type Fishing Vessel.

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1 Introduction

World health organization (WHO) defines health by emphasizing the condition of overall physical, mental and social well-being and not just experiencing an illness or disability. According to Blum, as cited by Mariam, there are four factors that influence the degree of human health, namely: behavioral factors, health services, heredity and environment. Blum concluded that the environment has the biggest contribution to one's health [1].

The term work environment is used to describe the conditions around people when they operate as the workers. In general there are five hazard in the work environment in terms of occupational safety and health aspects, including: physical, chemical, biological, biomechanical or ergonomic and psychosocial hazard all of which can negatively impact the health conditions and performance [2].

According to the Law of the Republic of Indonesia Number 1 of 1970 about Work Safety, a ship is one of the moving workplaces. Based on the function of the ship, there are several types, including passenger ships, cargo ships and fishing vessels. The definition of fishing vessels according to the Law of the Republic of Indonesia No. 45 of 2009 "ships, boats or other floating equipment used for fishing, support fishing operations, cultivation, transportation and processing of fish, fisheries training and fisheries research/exploration". One of the types are the pole and line ship, which are the fishing boats that are commonly used to catch skipjack and baby tuna [3]. Fishing vessels are one of the workplaces that are at high risk to the safety and health of the crew. The crew on fishing vessels work in all unpleasant conditions on the sea such as rain, storm and extreme temperatures. There are no fixed working hours and the rhythm of work is determined only by the sea and its catch. The crew experienced dangers of illness on fishing vessels include physical factors such as vibration, noise and temperature, chemical, biological, ergonomic and psychosocial factors [4].

The crew felt mechanical vibration which means the vibration throughout the body. Intense vibration with frequency between 4 Hz - 11 Hz can cause an increase in heart rate [5]. Low frequency vibrations can result in motion sickness, body instability and fatigue. High frequency vibrations affect vibrations in the human body that can worsen health risks, create discomfort for the body and affect performance degradation [4].

Negative effects on human health caused by increased noise can be observed through physiological and psychological effects. Damage to hearing organs in sailors who have worked for more than four years can be proven through medical examinations. Although statistically known that 5% of workers experience a hearing loss does not represent a significant value, it suggests that there is still a need to do an analysis of the increased risk of noise exposure in certain occupations [6]. In addition, changes in systolic blood pressure rise, diastolic blood pressure, arterial pressure, pulse pressure and heart rate are significantly affected by workplace noise exposure [7].

High temperatures, among others, can cause heat stress, heat stroke, heat rash and heat exhaustion. Heat exhaustion occurs due to working continuously in a hot environment that causes dehydration so that the volume of blood circulation to vital organs such as the brain and heart is decreased. The core body temperature has increased and the workers experience headaches, rapid heartbeat, nausea, fatigue to fainting [8].

In addition to chemicals such as asbestos and PAH, the exhaust gases from the combustion engine contains various chemicals and dust that will be easily inhaled. Unwittingly, exposure to the flue gas enters the respiratory and circulatory system and causes damage even though it takes a long time. Dust from exhaust gas can reduce lung function. The symptoms that are often caused by dust exposure are coughing and hard to breath [9].

Crews on fishing vessels are very susceptible to dermatoses on the hands and feet caused by biological factors in this case fish and other marine biota [10]. Ergonomics factors also affect the crew that improper ergonomics can cause greater health problems and affect work concentration thereby reducing productivity [11]. Besides being influenced by physical, ergonomic, biological and chemical factors at work, the crew is also influenced by psychosocial factors that lead to the increasing of stress level for the crew [12].

Based on the results of previous studies it can be said that the crew on a fishing vessel are exposed to unfavorable conditions in the work environment derived from physical factors such as hot or cold temperatures, noise, vibration; chemical factors such as dust generated from the combustion process when the ship's engine is operating, works in an unergonomic position, biological factors such as fish and marine life and psychosocial factors. The crew suffered diseases due to exposure to factors in the work environment include the decreasing of the hearing due to noise exposure, decreasing of lung function due to dust exposure, interference with blood pressure and pulse due to noise, vibration and temperature exposure. Physical, chemical, biological, ergonomic and psychosocial factors in the work environment can increase stress level on the crew. Besides being influenced by environmental factors, a human health is also influenced by his behavior. The use of personal protective equipment is one way that can be done to reduce or eliminate the negative effects of exposure to factors in the work environment such as vibration, temperature and noise which are part of physical, biological and chemical factors. The safe work environment, comfortable and free from hazards that can affect health makes workers excited and work well which will contribute to productivity and improve performance.

2 Research Methods

The data from this study are primary data obtained from questionnaires that have been filled out by 125 crews of pole and line fishing vessels as respondents. The number of respondents is determined based on the provisions of partial least square which is 5 times the number of indicators. Determination of indicators of each variable based on the theory and results of previous research on the work environment, behavior of using personal protective equipment, worker health and performance as a basis for model the influence of work environment and behavior on the health and performance of ship crews. In this study there are 25 indicators so that the number of respondents is 125 people.

The variables and indicators in this study are:

a) Exogenous latent variables Work environment (X1) with indicators: vibration (X1.1), noise (X1.3), temperature (X1.2); dust from engine exhaust (X1.4); fish and marine biota (X1. 5); ergonomic body position (X1.6); and a sense of safe and comfort in work (X1.7).
b) Exogenous latent variables Behavior (X2) with indicators for the use of personal protective equipment: work clothes (X2.1), gloves (X2.2), work shoes (X2.3), ear protectors (X2.4) and masks (X2.5).
c) Health endogenous latent variables (Y1) with indicators: blood pressure (Y1.1), pulse (Y1.2), hearing power conditions (Y1.3), lung function (Y1.4), dermatosis (Y1.5), aches in the waist and back (Y1.6), and work stress (Y1.7).
d) Endogenous latent variables Performance (Y2) with indicators of quality (Y2.1), quantity (Y2.2), punctuality (Y2.3), initiative (Y2.4), ability (Y2.5) and communication (Y2 .6).

The purpose of this study is to design a model of the effect of the work environment and the behavior of the use of personal protective equipment on the health and performance of fishermen on pole and line fishing vessels using Partial Least Square (PLS) analysis. The analysis steps according to the Partial Least Square carried out in this study as follows:

a) Get a concept-based model and theory for design structural models.
b) Designing a measurement model.
c) Make a path diagram (path diagram).
d) Estimate parameters.
e) Evaluate the model.
f) Draw conclusions.

3 Results and Discussion

3.1 Description of Research Results

Based on the response of the crew as respondents for work environment variables at work, 64.28% of respondents felt the vibration; 66.15% felt the noise; 72.05% felt the hot temperature; 42.13% breathe dust in its respiratory air; 74.01% interacted with fish and marine biota; 59.29% worked in an unergonomic position; and 52.17% felt insecure and uncomfortable while working.

For behavioral variables namely the use of personal protective equipment when working as much as 80.32% do not use work clothes; 84,92% do not use gloves; 85.83% do not use work shoes; 88.99% do not use ear protection equipment; 84.25% do not use masks.

For health variables found 60.63% of respondents suffer from hypertension, 84.25% have a normal pulse rate; 63.78% experienced hearing loss; 71.65% experienced impaired pulmonary function; 37.79% experienced symptoms of dermatosis in the form of itching and reddish rash; 68.50% experienced aches in the back and waist; and for work stress found 56.69% experienced mild stress, 10.24% experienced moderate stress and 9.41% experienced severe stress.

For the performance variable found 78.74% of respondents have good quality work; 68.11% have a good quantity of work; 86.09% of respondents are always on time when working; 68.29% have good initiative, 86.06% have good ability; and 94.29% can communicate well.

3.2 Results of Data Analysis

The data in this study were analyzed using the PLS analysis method to determine the relationship of indicators with their variables, the relationships between variables of the models designed and to determine the goodness of fit the model.

The design of structural models and measurement models based on theory and the results of previous studies. Structural models to explain the relationship between research variables while the measurement model to explain the relationship of each variable with its indicators. Based on the design of structural model and measurement model, a path diagram of this research is made which is a model of the influence of the work environment and behavior on the health and performance of the crew.

3.2.1 Design Structural Model

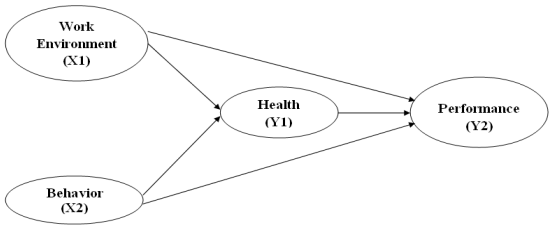

Fig. 1. Structural Model.

3.2.2 Design Measurement Model

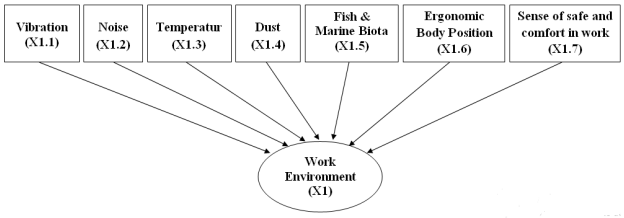

Fig. 2. Measurement Model of Work Environment Variable**.**

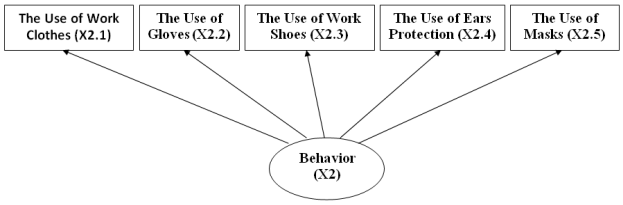

Fig. 3. Measurement Model of Behavior Variable**.**

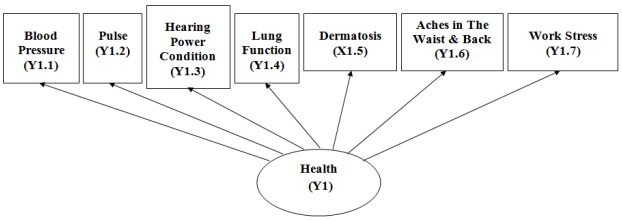

Fig. 4. Measurement Model of Health Variable.

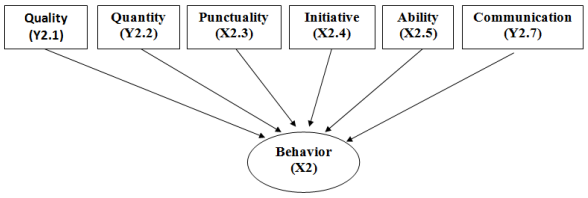

Fig. 5. Measurement Model of Performance Variable.

3.2.3 Path Diagram

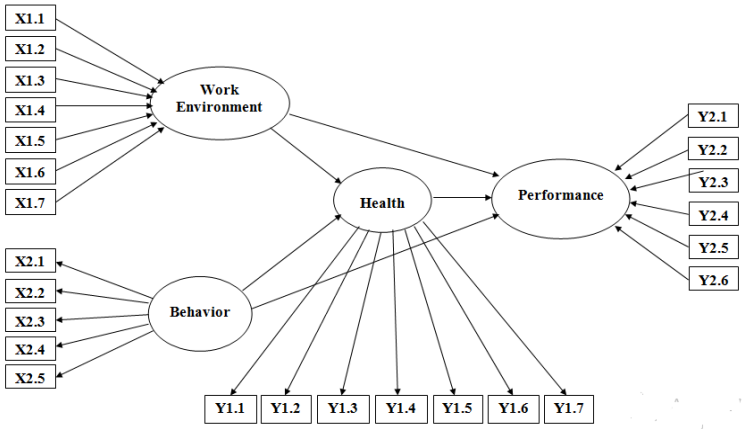

Fig. 6. Path Diagram Model of the influence of the work environment and behavior on the health and performance of the crew.

3.2.4 Parameter Estimation

In the structural model design, work environment and performance variables are formative while health and behavior variables are reflective. The score of each indicator or loading factor value for formative variables is seen from the outer weight value and the reflective form variable is seen from value the outer loading. An indicator is declared valid if it has a loading factor above 0.5 for the latent variable [13]. From Figure 7 shows that each indicator of each variable has a loading factor value above 0.5 that means the indicators are significant as a measure of the variable.

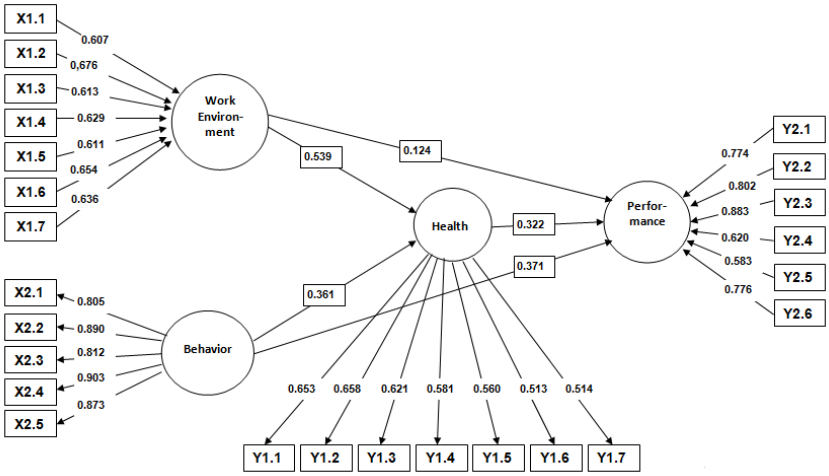

Fig. 7. Path Diagram with Loading Factor and Outer Weight Each Indicator.

3.2.5 Model Evaluation

a. Measurement Model (Outer Model)

For the variable with a reflective form, the model evaluates based on the values: i) discriminant validity, which compares the value of the square root of average variance extracted (AVE) of each construct with the correlation between other constructs in the model, if the square root of average variance extracted (AVE) is greater than the construct correlation with all other constructs is said to have good discriminant validity. Recommended measurement values must be greater than 0.50; ii) Composite reliability. Indicator group that measures a variable has good composite reliability if it has composite reliability ≥ 0.7; iii) Cronbach alpha value must be ≥ 0.7 [14].

Whereas for variables in the formative form of evaluation based on the t-statistics of loading results, the condition of t-statistics must be greater than the t-table value of 1.96 at a significance level of 5% and the P-value must be smaller than 0.005 [13].

Table 1. AVE Value, Composite Reliability and Cronbach Alpha

Variable Reflective	AVE	Composite Reliability	Cronbach Alpha
Behavior (X2)	0,749	0,759	0,764
Health (Y1)	0,693	0,743	0,746

In Table 1, it shows that the health and behavior variables have a composite value above 0.6 and a Cronbach alpha value of 0.7 which means that each indicator of each variable is able to measure each variable well and it can be said that the measurement model of the health and behavior variable has been reliable. The AVE value of the health and behavior variable is above the minimum criterion of 0.5 that means the health and behavior variable meets the convergent validity criterion.

Table 2. T-statistic value for formative variable

Formative Variable	Original Sample	Standard Error	T-statistic	P-value
Work Environment (X1)				
X1.1	0.607	0.134	4.530	0.002
X1.2	0.676	0.162	4.173	0.000
X1.3	0.613	0.289	2.121	0.001
X1.4	0.629	0.263	2.391	0.000
X1.5	0.611	0.306	1.997	0.002
X1.6	0.654	0.320	2.043	0.000
X1.7	0.636	0.215	2.958	0.000
Performance (Y2)				
Y2.1	0.774	0.162	4.778	0.000
Y2.2	0.802	0.151	5.311	0.000
Y2.3	0.883	0.100	8.830	0.000
Y2.4	0.620	0.153	4.052	0.000
Y2.5	0.583	0.168	3.470	0.001
Y2.6	0.777	0.164	4.737	0.000

In Table 2 shows that the T-statistic value of each indicator > 1.96 and P-value < 0.05 that means the measurement model of the work environment and performance variables is valid and reliable. Indicators on each variable are able to measure the variable properly.

From the results of test the measurement model (outer model) above reveals:

- Work environment variables are significantly formed by the seven indicators examined in this study, namely: 1) vibration; 2) noisy; 3) temperature; 4) dust; 5) fish and marine biota; 6) ergonomic work body position; and 7) a sense of safe and comfort in work.
- Behavioral the use of personal protective equipment variables are significantly reflected by the 5 indicators studied, namely: 1) use of work clothes; 2) use of gloves; 3) use of work shoes; 4) use of ear protectors; and 5) use of masks.
- Health variables are significantly reflected by the seven indicators studied namely: 1) blood pressure; 2) pulse; 3) hearing power conditions; 4) lung function; 5) dermatosis; 6), aches in the waist, shoulders and back; and 7) work stress.
- Performance variables are significantly formed by the six indicators examined in this study, namely: 1) quality of work; 2) work quantity; 3) punctuality; 4) initiative; 5) ability; and 6) communication

b. Structural Model (Inner Model)

The structural model (inner model) is a model that describes the relationship between latent variables. Evaluation of structural models is carried out to see the feasibility of the designed model known as Goodness of Fit which is evaluated using R-square (R^2) and Q-square (Q^2) values.

Endogenous variables in this study are health variables and performance variables. The R^2 value of each endogenous variable is as follows:

- Measurement of health variables obtained R^2 of 0.637 or 63.70%. This indicates that health variables are influenced by work environment and behavior variables by 63.70%.

- Performance variable measurements obtained R2 of 0.521 or 52.10%. This indicates that the performance variable is influenced by work environment, behavior and health variables by 52.10%.

Thus, the value of predictive relevance (Q^2) is obtained as follows:

$$Q^2 = 1 - [(1 - R21) (1 - R22)]$$
$$Q^2 = 1 - [(1 - 0.637) (1 - 0.521)]$$
$$Q^2 = 1 - 0.174$$
$$Q^2 = 0.826$$

The calculation results show the predictive relevance value (Q^2) is almost close to one (1) that is equal to 0.826 or 85.60% thus the model deserves to be said to be very good. The predictive relevance value of 82.60% indicates that the diversity of data can be explained by the built model of 82.60% while the remaining 17.40% is explained by other variables not yet contained in the model.

These results are consistent with the results of previous studies on the influence of factors on the work environment on health and performance. According to Kristiansen there are certain unique characteristics of seafarers' position that must be considered when studying the work environment on board. The working environment on ships has hot or cold temperature conditions which have a large impact on working conditions. Besides that it is also influenced by noise and vibration [15]. According to Orosa et al, ergonomics design working conditions to suit workers so that work is safer and more efficient. Implementing ergonomics in the work environment makes workers more comfortable and it increases productivity. Comfort in working ergonomically is not only influenced by body position when working or repetitive movements but is also influenced by factors in the work environment such as temperature, vibration and noise [16].

Wang, et al in their study concluded the level of hypertension and hearing loss increases with increasing years of work. The results showed a positive relationship between noise exposure with hypertension and hearing loss [17]. Kumar et al, examined the exposure of whole-body vibrations and noise to blood pressure and pulse. The results showed an average pulse rate at the time it began to be exposed after it declined and continued. Blood pressure increases with increasing noise level accompanied by vibration exposure [18]. The conclusions drawn from the study Kaerlev et al are sailors and fishermen who work in the engine room have a higher risk of hearing loss due to noise exposure. Besides, noise exposure does not only cause hearing loss, but also acts as a stress trigger [19]. Lundgren et al discuss about decreasing productivity due to heat stress at several workplaces in Chennai, India shows that heat stress has a significant impact on productivity decline [20].

Oktaviani *et al* in their research on respiratory complaints due to dust in the workplace concluded dust particles can cause respiratory complaints in workers such as coughing and shortness of breath even though dust levels are still below the threshold value, this is due to the length of work, duration of exposure and use of protective equipment undisciplined self when working [21]. Reinhold, et al which concluded the use of personal protective equipment can reduce the impact of exposure to factors on the work environment significantly so as to prevent occupational diseases [22]. Suwondo *et al* which states the work environment influences employee performance and a comfortable work environment will improve employee performance [23]. Boles et al which states that workers' health affects their productivity as workers who experience work stress will affect their presence at work [24].

4 Conclusions

Evaluation of the measurement model on the behavioral variables and health variables shows all valid and reliable indicators and is able to measure each variable based on the AVE value above the minimum criterion of 0.5, composite reliability value ≥ 0.6 and Croncbach alpha value ≥ 0.7. Evaluation of the measurement model on the work environment variables and performance variables shows all valid and reliable indicators and is able to measure each variable with an outer weight value > 0.5, T-statistics for each indicator > 1.96 and P- value < 0.05.

Measurement of health variables obtained R^2 of 0.637 or 63.70%. This indicates that health variables are influenced by work environment and behavior variables by 63.70%. Performance variable measurements obtained R^2 of 0.521 or 52.10%. This indicates that the performance variable is influenced by work environment, behavior and health variables by 52.10%.

The structural model evaluation results show the model built is worth mentioning very well with a Q^2 value or relevance of prediction of 0.826 indicating 82.60% of the diversity of data can be explained by the model built while the remaining 17.40% is explained by other variables not yet contained in the model.

References

[1] I. Mariam, "Antropologi dan Sosiologi kesehatan Sosial dan Budaya," 2015. [Online]. Available: http://www.slideshare.net.

[2] ILO, "International Hazard Datasheets on Occupation. International Labour Organization," 2000. [Online]. Available: www.ilo.org/safework/info/publications/WCMS.../lang--en/.

[3] A. Runny, "Teknik Pengoperasian Alat Tangkap Huhate atau Sering Disebut dengan Pole and Line," 2017. [Online]. Available: http://purseine.blogspot.co.id/2017/01/huhate-atau-sering-disebut-dengan-pole.html.

[4] ILO, "Seafarers Bill of Right," *Guidance of Health and Safety*, 2013. .

[5] D. Jegaden, "Mechanical Vibration," *Textbook of Maritime Medicine*, 2013. [Online]. Available: www.textbook.ncmm.no.

[6] A. Nikolić and E. Nikolić, "Controlling risk due to noise on ferryboats," *Saf. Secur. Traffic Rev.*, vol. 25, no. 4, pp. 387–394, 2013.

[7] S. Kalantary, A. Dehghani, M. S. Yekaninejad, L. Omidi, and M. Rahimzadeh, "The effects of occupational noise on blood pressure and heart rate of workers in an automotive parts industry," *ARYA Atheroscler.*, vol. 11, no. 4, p. 215, 2015.

[8] R. G. Huss, S. B. Skelton, K. L. Alvis, and L. A. Shane, "Heat Stress Management Program Improving Worker Health and Operational Effectiveness: A Case Study," *Workplace Health Saf.*, vol. 61, no. 3, pp. 128–133, 2013.

[9] D. I. Novtasari and Y. Wijayanti, "Faktor Individu, Paparan Debu, dan CO dengan Gambaran Faal Paru Petugas SPBU," *HIGEIA (Journal Public Heal. Res. Dev.*, vol. 2, no. 4, pp. 553–563, 2018.

[10] D. Corry, "Gambaran Kelainan Kulit Pada Nelayan di Yong Panah Hijau Kelurahan Labuhan Deli Kecamatan Medan Belawan Tahun 2008."

[11] T. Allenbrand, "Everything You've Ever Wanted to Know About Ergonomic," *Workspace Design Magazine*, 2015. [Online]. Available: http://workdesign.com.

[12] L. S. Crystal; Wei, "Optimizing Work Performance under Stress for the Merchant Navy," *14th NUROP Congr. Singapore. Natl. Univ. Singapore*, 2009.

[13] M. Tedjo, S. Sugito, and S. Suparti, "Analisis Faktor-faktor Yang Mempengaruhi Keputusan

Penggunaan Transportasi Pribadi Pada Mahasiswa Menggunakan Pendekatan Partial Least Square (Studi Kasus Pada Universitas Diponegoro Semarang)," *J. Gaussian*, vol. 6, no. 2, pp. 211–219, 2017.

[14] I. Jaya and I. M. Sumertajaya, "Pemodelan persamaan struktural dengan partial least square," *Semnas Mat. dan Pendidik. Mat.*, vol. 1, pp. 118–132, 2008.

[15] M. Lang, "An investigation of organizational culture and job satisfaction on board industrial and cruise ships." Norges teknisk-naturvitenskapelige universitet, Fakultet for …, 2011.

[16] J. A. Orosa and A. C. Oliveira, "Assessment of work-related risk criteria onboard a ship as an aid to designing its onboard environment," *J. Mar. Sci. Technol.*, vol. 15, no. 1, pp. 16–22, 2010.

[17] S. Wang, Q. Qin, L. Liu, L. Han, and Y. Chen, "A cross-sectional study on the effects of occupational noise exposure on hypertension or cardiovascular among workers from automobile manufacturing company of Chongqing, China," *J. Biomed. Sci. Eng.*, vol. 6, no. 12, p. 1137, 2013.

[18] S. Kumar, P.; Saran, V.; Harsha, "Effect of Noise and Vibration on Human Physio-logical Parameters," *MIT Int. J. Mech. Eng.*, vol. 4, no. 1, pp. 58–62, 2014.

[19] L. Kaerlev, A. Jensen, P. S. Nielsen, J. Olsen, H. Hannerz, and F. Tuchsen, "Hospital contacts for noise-related hearing loss among Danish seafarers and fishermen: a population-based cohort study," *Noise Heal.*, vol. 10, no. 39, p. 41, 2008.

[20] K. Lundgren, K. Kuklane, and V. Venugopal, "Occupational heat stress and associated productivity loss estimation using the PHS model (ISO 7933): a case study from workplaces in Chennai, India," *Glob. Health Action*, vol. 7, no. 1, p. 25283, 2014.

[21] D. A. Oktaviani and C. I. Prasasti, "The Physical and Chemical Air Quality, Worker's Characteristics, and Respiratory Symptoms Among Printing Workers in Surabaya," *J. Kesehat. Lingkung.*, vol. 8, no. 2, pp. 195–205, 2016.

[22] K. Reinhold, S. Kalle, and J. Paju, "Exposure to high or low frequency noise at workplaces: differences between assessment, health complaints and implementation of adequate personal protective equipment," *Agron. Res.*, vol. 12, no. 3, pp. 895–906, 2014.

[23] E. M. Sutanto and D. I. Suwondo, "Hubungan lingkungan kerja, disiplin kerja, dan kinerja karyawan," *J. Manaj. dan kewirausahaan*, vol. 17, no. 2, pp. 135–144, 2015.

[24] M. Boles, B. Pelletier, and W. Lynch, "The relationship between health risks and work productivity," *J. Occup. Environ. Med.*, vol. 46, no. 7, pp. 737–745, 2004.