

Association of Noise Exposure and Physical Workload on Systolic Blood Pressure of Ceramic Industry Workers

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Abstract

Noise is a major problem in modern industrial activities. The use of machines in industry and inseparable design of work between humans and machines makes workers exposed to noise as one of the physical hazards in the work environment. Noise can cause physiological reactions such as systolic and diastolic blood pressure disorders. However, systolic blood pressure response is more sensitive to changes. The systolic pressure after loading is normally up (20 mmHg), the rest is considered abnormal and is considered one of the risk factors for cardiovascular disease. Blood pressure is a multifactorial health indicator. In addition to noise, blood pressure is also influenced by the physical workload that workers receive as one of the factors of workload. The purpose of this study is to examine the relationship of noise and physical workload to an increase in systolic blood pressure. This is a cross sectional design and observational analytical study with statistical tests using spearman. Respondents were determined through simple random sampling technique that results in a sample of 36 ceramics industry workers in the production line section. The results showed the value of the noise relationship ($r = 0.581$) towards the increase in systolic blood pressure. Physical workload showed a relationship value of ($r = 0.666$) towards the increase in systolic blood pressure. The direction of the relationship between the independent variable and the dependent variable is positive, which means that the higher the noise level and physical workload, the higher the risk of abnormal systolic blood pressure.

Keywords: *noise, physical workload, systolic pressure*

Introduction

The main problem of occupational health in industrialized countries is noise. According to WHO in 1995 it was estimated that 14% of the workforce in the industrial country was exposed to noise of more than 90 dB. At least 7 million people or 35% of the total population in America and Europe were exposed to noisy 85 dB or more. In Poland it was estimated that 600,000 of the 5 million industrial workers had the risk of being exposed to noise. This illustrates the noise in the work environment has been a major problem that threatens the health of workers⁽¹⁾.

Noise is all the unwanted noise that comes from the tools of the production process or work tools which at a certain level can cause hearing loss. Noise is one of the important aspects in industrial hygiene and noise exposure is a form of hazard that can be controlled so as to reduce the impact caused. Noise exposure caused 54.7% of the workforce to experience non-auditory problems and only 18.7% of the workforce experienced auditory problems. Based on the study noise exposure has a greater non-auditory risk than that of auditory⁽²⁾. Non-auditory effects due to noise in workers can be physiological, psychological and communication disorders. One of the non-auditory effects of noise exposure is a disturbance in cardiovascular and circulatory system caused by excessive production of adrenaline hormone, resulting in an increase in the frequency of heart rate and blood pressure⁽³⁾. The production machine produces a noise level above the set threshold value of 85 dB. This noise is produced from production machines such as the GF

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Box Feeder for the extruder stage which is used to check mass density so that the product is not easily broken and the crusher machine used to destroy ceramics that fails to pass the quality control stage.

Increased blood pressure is one factor in the occurrence of cardiovascular disease. According to WHO data, 31% of the 56.6 million deaths worldwide were caused by cardiovascular disease in 2012. In Indonesia cardiovascular disease recorded in Indonesian Basic Health Research was the highest cause of death by 1.5%⁽⁴⁾. Factors that affect blood pressure increase in workers are multifactorial. In addition to the danger that comes from the work environment in the form of noise, physical workload is also a factor that influences the risk of increased blood pressure. The physical workload can be in the form of lifting, running and carrying activities.

Physical work produces energy that meets energy consumption needs. Assessment of physical workload can be measured by an objective method of measuring the pulse during work. The higher the pulse count measured the higher the physical workload received by the worker. Pulse is one system that runs synergistically with blood pressure. Thus, the higher the burden of physical works, the higher the increase in blood pressure⁽⁵⁾. In accordance with the results of preliminary observations made by the researchers, the works in the ceramics industry is highly dependent on physical activities. Activities in the ceramics production process includes elevating the arrangement of ceramics to be assessed by quality control and preceded with packing process to ensure all ceramic surfaces get the perfect glazing process and arranging the ceramics on the pallet to be stored in the warehouse.

Based on the explanation, this study aims to analyse the relationship of work environment factors in the form of noise exposure and occupational factors in the form of physical workload to an increase in systolic blood pressure to workers in the ceramic production line.

Material and Method

This study aims to analyze the relationship between noise exposure and physical workload to increase

systolic blood pressure in ceramic industry workers in the production line section. This is an observational analytic study because the researcher did not provide an intervention and only looked for the relationship of the variables studied. In terms of time, this is a cross sectional study because observations were made at one time. The study period was conducted in May 2019. The study population was 40 people and the sample was taken using the simple random sampling method with the Slovin formula which resulted in 36 research samples.

The independent variables tested were noise exposure and physical workload, while the dependent variable was systolic blood pressure. All variables were obtained through measurements as explained below.

1. Noise Measurement

The measurement of noise intensity was carried out at three points of the line production area of forming, glazing and packing & loading. Measurements were made using the Sound Level Meter (SLM) of Svantek type and carried out by the operator of the Occupational Safety Technical Unit of the East Java Province Manpower and Transmigration Office. Test method is based on SNI 7231: 2009 concerning Noise.

2. Measurement of Physical Workload

The measurement of physical workload uses the 10 pulse method to determine the Work Pulse Rate which is then classified based on the Cardiovascular Load formula (% CVL). Measurement was made using palpation method on the worker's pulse by medical personnel of nurse. The measurement technique begins by pressing the on button on the stopwatch along with the first pulse and turning off the stopwatch on the 10th pulse. The number of seconds produced was then recorded. The pulse measurement was carried out four times by 8:30 a.m., 9:30 a.m., 10:30 a.m. and 11:30 p.m. to find out the average pulse rate at work.

$$\%CVL = \frac{100 (\text{Working pulse} - \text{Resting pulse})}{\text{Max pulse} - \text{Resting pulse}}$$

Table 1. Categories of Physical Workload

Workload Rate	CVL Category	CVL Score
0	Light	< 30 %
1	Moderate	30 to 60 %
2	Heavier	60 to 80 %
3	Heavy	80 to 100 %
4	Very heavy	> 100 %

Source : Tarwaka, 2015

3. Measurement of Systolic Blood Pressure

Blood pressure measurement was carried out by medical staff of a nurse prior to working at 07:45 WIB and after working at 12:00 WIB. Measurements were performed using a manual sphygmomanometer and stethoscope.

Data collected from research results are processed in several stages. First, the data was coded numerically to maintain data privacy and facilitate data input activities.

The data analysis activity aims to find the significance of the relationship, the strength of the relationship and the direction of the relationship between the independent variable and the dependent variable. The significance in the spearman test can be seen from the presence of two stars (**) on the strength of the relationship. The strength of the relationship can be seen from the value of the correlation coefficient (r). The correlation coefficient is between 1 and -1. Positive and negative signs indicate the direction of the relationship.

Table 2. Strength and Direction of Correlation between Research Variables.

	Coefficient Correlation Value	Intepretation
Correlation Strength	0,000 – 0,199	Very weak
	0,200 – 0,399	Weak
	0,400 – 0,599	Fair
	0,600 – 0,799	Strong
	0,800 – 1,000	Very strong
Correlation Direction	Positive	Have the same direction, the higher xi value the higher yi value.
	Negative	Have the opposite direction, the higher xi value the lower yi value.

Finding

1. Measurement Results from Noise in the Production Line Area

Noise measurement in the ceramic industry is

divided into three points on the line production section, measuring with Sound Level Meter (SLM) with the following results.

Table 3. Measurement Results from the Noise Point in the Production Line

Measurement Point	Measurement Time	Noise intensity	Duration of Exposure	Types of Noise	Information
Forming	10.45	85.9 dB	8 hours	Continue	> NAB
Glazing	11.00	80.1 dB	8 hours	Continue	< NAB
Packing and Loading	11.15	85.3 dB	8 hours	Continue	> NAB

Noise measurement was carried out at each sound source in the PT KIA Ceramic MAS, Gresik line production area. The highest noise was generated from the forming area. The source of noise in this area was caused by the use of GF Box Feeder machines or extruder machines. The measurement of noise intensity in units with continuous noise types was carried out once with a distance of one meter from each sound source, the average noise intensity in each unit was then calculated.

Based on the table, the point of forming and packing and loading has a noise intensity above the threshold value of 85dB. The highest noise point in the forming area was 85.9 dB.

2. Results of Measurement of Physical Workloads

The physical workload was measured by calculating the 10 pulse method which was then calculated using the calculation of the cardiovascular load (CVL) percentage.

2.1 DNI data were taken by measuring resting pulse before workers begin their work.

2.2 DNK data were taken by measuring the pulse when the workers start doing their work, this include:

- a. DNK Measurement 1 at 08.30 WIB
- b. DNK Measurement 2 at 09.30 WIB
- c. DNK 3 Measurement at 10.30 WIB
- d. DNK 4 Measurement at 11.30 WIB

The results of the measurement of the average time of the 10 pulse workers were included in the 10 pulse method equation that the workers' pulse per minute was

obtained. After this calculation, the physical workload was calculated by the cardiovascular load (CVL) method as shown below:

The frequency distribution of the level of physical workload on line production workers is presented in the following table:

Table 4. Distribution of Respondents based on Physical Workload Levels on Workers

Physical Workload Levels	Frequency (n)	Percentage (%)
Light	11	31
Moderate	25	69
Heavier	0	0
Heavy	0	0
Very heavy	0	0
Total	36	100

The distribution shows that the highest category is moderate physical workload by 25 (69%) workers.

3. Results of Systolic Blood Pressure Measurement

The average systolic blood pressure before working and after working increased, but the categorization of an increase in blood pressure is based on a normal increase and an abnormal increase. Increased systolic blood pressure is in the normal category if the increase is 20 mmHg from the initial measurement. If the increase

exceeds 20 mmHg it is categorized as an abnormal increase.

Table 5. Distribution of Respondents based on Increased Systolic Blood Pressure of Workers

Increased Systolic Blood Pressure	Frequency (n)	Percentage (%)
Normal Increase (≤ 20 mmHg)	10	28
Abnormal increase (> 20 mmHg)	26	72
Total	36	100

A total of 26 (72%) line production workers experienced an increase in systolic blood pressure in the abnormal category before and during work.

4. Relationship of Noise Intensity and Physical Workload to Systolic Blood Pressure

Analysis of the relationship between the intensity of noise and physical workload to an increase in systolic blood pressure was carried out by the following table:

Table 6. Correlation between noise, physical workload to systolic blood pressure

Variables	Increased Systolic Blood Pressure				Total		Coefficient Correlation
	Normal		Abnormal				
	n	%	n	%	n	%	
Noise Intensity							
Noisy	4	14	25	86	29	100	0,581
Not noisy	6	86	1	14	7	100	
Physical Workload							
Light	8	73	3	27	11	100	0,666
Moderate	2	8	23	92	25	100	

.Based on table 6, 25 (86%) of workers exposed to noise experienced an increase in systolic pressure, while 1 (14%) worker from the group of workers who were not exposed to noise experienced an increase in systolic pressure.

The results of data analysis using the Spearman rho test (Coefficient Correlation) showed a value of 0.581, which means that noise exposure has a strong relationship and a positive relationship with systolic blood pressure. Therefore, the higher the exposure the higher the risk of increasing systolic blood pressure

in the abnormal category. Relationship of noise and systolic blood pressure in ceramics industry workers is significant.

This research is in line with the theory of the mechanism of noise stimulation and blood pressure. The theory states that mechanism of vascular disorders in noisy stimulation can be explained as follows. The noisy stimulated organ has an increased task to continue excitement to the centre. This increase requires energy obtained from glucose metabolic processes. This

metabolic process requires oxygen. Every increase in metabolism in tissue cells is always accompanied by an acute increase in blood flow to the tissues. As a result, there is a reduction in active tone in the vascular wall muscles and contractile properties of the capillary endothelium which cause vasodilation of arteriole, venule, metarteriole, pre-capillary and capillary sphincter⁽⁶⁾.

Noise has a stronger relationship to the increase in systole than diastole because systolic pressure tends to be more sensitive to noise than diastolic pressure. Noisy is captured as a stressor by the body which then activates the hypothalamus and then controls the endocrine system, the sympathetic system and the adrenal cortex. Activation of various organs and smooth muscles that are in the control of the sympathetic nervous system such as increasing heart rate is a form of response from the sympathetic nervous system to the impulse of the hypothalamus. The sympathetic nervous system also gives impulses to the adrenal medulla to release epinephrine and norepinephrine to the bloodstream. Both of these hormones have vasoconstrictive effects on blood vessels, causing the heart to pump blood more strongly and an increase in blood pressure in workers. Both of these hormones only affect systolic blood pressure while diastole tends to remain.

Based on table 6, 23 (92%) workers from the physical workload group were experiencing an increase in systolic pressure. A total of 3 (27%) workers from the group with light physical workload experienced an increase in systolic pressure.

The results of data analysis using the Spearman rho test (Coefficient Correlation) showed a value of 0.666 which means that the physical workload relationship has a strong relationship and positive relationship direction to systolic blood pressure. Therefore, the higher the physical workload the higher the risk of increasing systolic blood pressure in the abnormal category. The relationship between physical workload and systolic blood pressure in ceramics industry workers is significant.

The results of this study are in line with the theory stated by Rodahl (1999) in the Tarwaka book (2014) that the higher the category of physical workload the higher the pulse counts. Pulse has a work that is synergistic with blood pressure so that an increase in blood pressure is more likely to occur in workers who have a moderate

to high physical workload.⁽⁵⁾

Conclusion

Noise above the threshold value allowed in the ceramic production line section occurs at the point of forming and loading packing. Noise exposure has a significant relationship to increased systolic blood pressure. The relationship is strong and positive, so that the higher the noise exposure, the greater the likelihood of an abnormal increase in systolic blood pressure. Most workers have a moderate workload of physical work. Physical workload has a significant relationship to an increase in systolic blood pressure. Relationships that appear are strong and positive. The higher the physical workload the higher the possibility of an increase in systolic blood pressure.

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References

1. Roestam. Ergonomics Application Training for Productivity. Jakarta: Community Medicine, Medical School University of Indonesia; 2003.
2. Hadi S. Factors Affecting Increased Blood Pressure in Workers with Noise Exposure at PT. X, Indonesia; 2014
3. Sasongko. Environmental Noise. Semarang: Publishing Institute Diponegoro University; 2000.
4. National Institute of Health Research and Development, Ministry of Health of the Republic of Indonesia 2013. Lap Nas 2013. 2013;1–384.
5. Tarwaka. Industry Ergonomic : Base Ergonomic and Application at Workplace. Surakarta: Harapan Press; 2015.
6. Schmidt F, Kolle K, Kreuder K, Schnorbus B, Wild P, Hechtner M, et al. Nighttime aircraft noise impairs endothelial function and increases blood pressure in patients with or at high risk for coronary artery disease. Clin Res Cardiol [Internet]. 2015;104(1):23–30. Available from: <http://link.springer.com/10.1007/s00392-014-0751-x>