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ORIGINAL ARTICLE

Relationship between noise intensity and increased blood pressure in workers

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ABSTRACT

Occupational noise, particularly from industrial machinery and equipment, is a potential risk factor for elevated blood pressure. This cross-sectional study aimed to investigate the association between noise intensity and blood pressure changes among workers in the GCS department of PT. Pertamina EP Asset I Pangkalan Susu Field. All workers in five GCS units (n=30) participated. Noise intensity was measured using a sound level meter, and blood pressure was measured before and after work. Data analysis employed chi-square and paired t-tests with a significance level of 5%. Results showed no significant association between noise intensity and systolic blood pressure increase (p=0.317). However, a significant relationship was found between noise intensity and diastolic blood pressure increase (p=0.001). It can be concluded that there is a significant difference in systolic and diastolic blood pressure before and after work. Although noise intensity does not directly affect systolic blood pressure, it has a significant impact on increasing diastolic blood pressure.

Keywords: noise intensity, systolic blood pressure, diastolic blood pressure

Introduction

Noise pollution in workplaces has become a significant global issue, with industrial and transportation sources being major contributors.[1] This environmental hazard can lead to various adverse effects on workers' health and productivity, including hearing damage, psychological impacts, reduced concentration, and increased accident risks. The prevalence of hearing loss and tinnitus among industrial workers is notably higher than in the general population.[2] Studies estimate that 17-42% of workers are exposed to hazardous workplace noise.[3,4] Prolonged exposure to occupational noise is associated with increased prevalence of hearing loss, hypertension, and elevated cholesterol.[5] The prevalence of noise-induced hearing loss ranges from 21.7% to 34.5% in some industries.[6]

Environmental noise exposure has been increasingly recognized as a significant health concern, particularly for its cardiovascular effects. Studies have shown that persistent exposure to high levels of noise, especially from traffic and aircraft, is associated with an increased risk of cardiovascular diseases, including hypertension, myocardial infarction, and stroke.[7,8] The mechanisms underlying these effects involve sleep disturbances, increased stress hormone levels, and oxidative stress, leading to endothelial dysfunction and

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arterial hypertension.[9] Nighttime noise is particularly detrimental, causing disruptions in sleep structure and vegetative arousals. Recent research has revealed that noise exposure can activate NADPH oxidase, uncouple endothelial nitric oxide synthase, and promote vascular infiltration with inflammatory cells.[8,9]

PT. Pertamina EP Asset 1 Pangkalan Susu Field is a major oil processing company situated in Sumatra, specifically in Pangkalan Susu, Langkat Regency. The Gathering Compressor Station (GCS) unit is responsible for operations related to oil wells, distributed across various locations. The oil produced is then pumped to Gathering Stations (GS/SK) before being collected at the Central Production Gathering Station (PPP) located in Bukit Jengkol. The GCS unit is a critical facility that must be maintained to ensure the smooth operation of PT. Pertamina EP Asset 1 Pangkalan Susu Field. Within the Gathering Compressor Station (GCS) unit of the Pangkalan Susu operational area, there are five Gathering/Compressor Stations (GCSs) located both onshore and offshore. The onshore stations are Unit I and Unit III Gebang, situated in Palutabuhan Timur. The offshore stations are Unit V, Unit IV, and Unit II, located in Palutabuhan Barat. Each station is staffed with 5 to 8 workers, divided into two shifts: day and night. These compressors are utilized to facilitate the supply of petroleum.

Operating continuously for 24 hours, compressors serve as a significant source of noise pollution in the PT. Pertamina EP Pangkalan Susu work environment. Noise level measurements conducted at the Gathering Compressor Station (GCS) using a Sound Level Meter revealed readings ranging from 80 to 102 dB. These values exceed the maximum permissible noise exposure limit of 85 dB for an 8-hour workday, as stipulated in the Indonesian Minister of Manpower Regulation Number 5 of 2018. Chronic exposure to noise at such levels can induce a variety of health problems among workers. Given the non-compliance of the work environment with occupational safety and health standards, this study aims to investigate the correlation between noise intensity and elevated blood pressure among workers in the GCS department of PT. Pertamina EP Asset 1 Pangkalan Susu Field. This research is expected to contribute to understanding the adverse health effects of noise on workers and to provide recommendations for noise control in the workplace.

Method

This cross-sectional observational study aims to investigate the association between noise intensity (independent variable) and elevated blood pressure (dependent variable) among workers in the Gathering Compressor Station (GCS) of PT. Pertamina EP Asset 1 Pangkalan Susu Field. Data on noise levels and blood pressure were collected simultaneously from all study participants at a single point in time. Statistical analyses were conducted to test the hypothesis of a relationship between the two variables.

This study centered on 30 employees working across five Gathering Compressor Stations (GCS) within PT. Pertamina EP Asset 1 Pangkalan Susu Field. To obtain a comprehensive understanding of noise exposure, sound levels within the work environment were measured both before and after work hours. Additionally, employees' blood pressure was measured using a digital sphygmomanometer before and after their shifts by healthcare professionals to identify potential cardiovascular health impacts associated with noise exposure. A structured questionnaire was administered to collect data on demographics (age, length of service, daily work hours), work-related behaviors (Personal Protective Equipment or PPE usage), medical history (hypertension), and lifestyle habits (smoking). This data provided a deeper context for the characteristics of respondents and potential factors influencing the research outcomes. Beyond primary data, the study also utilized secondary data obtained from PT. Pertamina EP Asset 1 Pangkalan Susu Field, including more detailed demographic and occupational information on respondents, as well as company documents related to safety and health standards and procedures. Indonesia's Ministerial Regulation No. 5 of 2018 concerning Occupational Safety and Health was employed as a reference framework to evaluate the working conditions at the research sites.

Univariate analysis aims to describe the characteristics of each individual research variable. Frequency distributions and percentages for each variable are presented in tables or graphs to provide a clear overview of the characteristics of the study sample. To examine the relationship between the independent and dependent variables (blood pressure), a chi-square test was employed. This test was conducted at a significance level of 5% ($\alpha = 0.05$). If the resulting p-value is less than or equal to 0.05 ($p \leq 0.05$), it can be concluded that there is a significant relationship between the independent variable and an increase in blood pressure. Conversely, if the p-value is greater than 0.05 ($p > 0.05$), there is no significant relationship between the two variables.

Results

As indicated in Table 1, the noise intensity at the GCS varied significantly, with Unit III exhibiting the most intense noise at 102 decibels. In contrast, the quietest area was Unit I, recording a noise level of 81.7 decibels. Notably, four measurement points at the GCS exceeded the regulatory noise limit of 85 decibels.

Table 1. Noise intensity measurement results of the GCS section

Measurement point	Measurement result	Information
Unit I	81.7 dB	≤ 85 dB
Unit II	92.9 dB	> 85 dB
Unit III	102 dB	> 85 dB
Unit IV	96.5 dB	> 85 dB
Unit V	93.9 dB	> 85 dB

Analysis of the frequency distribution of demographic variables indicated that a substantial majority of the study participants were aged 45 years and above (56.7%). Additionally, a large proportion of respondents had a work experience exceeding 20 years (66.7%) and worked for more than 8 hours daily (63.3%). In terms of health risk factors, the findings showed that a significant majority of respondents did not have a history of hypertension (86.7%). However, approximately 30% of the sample reported being current smokers. The demographic profile, dominated by an older age group with extensive work experience and relatively long daily working hours, implies that the study population may be at increased risk for various health problems associated with age and occupational factors. Although the prevalence of hypertension was relatively low, the proportion of respondents engaging in smoking behavior was substantial.

Table 2. Characteristics of respondents

Variable	n	%
Age		
≤ 45 years	13	43.3
> 45 years	17	56.7
Length of service		
≤ 20 years	10	33.3
> 20 years	20	66.7
Working hours		
≤ 8 hours	11	36.7
> 8 hours	19	63.3
History of hypertension		
Yes	4	13.3
No	26	86.7
Smoking habit		
Yes	9	30.0
No	21	70.0

Of the 30 participants, 60% (n=18) were exposed to noise levels exceeding 85 dB, while the remaining 40% (n=12) were exposed to noise levels of 85 dB or less. The analysis revealed that a majority of participants exposed to high noise levels (83.3%) experienced an increase in systolic blood pressure, compared to those exposed to low noise levels (16.7%). A similar pattern was observed for diastolic blood pressure, with 53.3% of participants in the high noise exposure group experiencing an increase, whereas 46.7% in the low noise exposure group did not.

Table 4 reveals an intriguing trend. Among respondents exposed to noise levels ≤ 85 dB, a substantial 75% (n=9) experienced an increase in systolic blood pressure. This proportion rose to 88.9% (n=16) for those exposed to noise levels exceeding 85 dB. A chi-square test was conducted to assess the association between noise intensity and elevated systolic blood pressure. The resulting p-value of 0.317 exceeded the conventional alpha level of 0.05. Consequently, the null hypothesis (H_0) cannot be rejected. This suggests

that there is insufficient statistical evidence to conclude a significant relationship between these two variables.

Table 3. Noise intensity and blood pressure

Variable	n	%
Noise intensity		
≤ 85 dB	12	40.0
> 85 dB	18	60.0
Systolic blood pressure		
Not increase	5	16.7
Increase	25	83.3
Diastolic blood pressure		
Not increase	14	46.7
Increase	16	53.3

Table 4. Relationship between noise intensity and increased systolic blood pressure

Noise intensity	Increase in systolic blood pressure				p	RP	95%CI	
	Not increase		Increase					
	n	%	n	%			Lower	Upper
≤ 85 dB	3	25.0	9	75.0	0.317	2.25	0.373	19.060
> 85 dB	2	11.1	16	88.9				

The table shows the relationship between noise intensity and increased diastolic blood pressure. Subjects exposed to noise intensity greater than 85 dB (53.3%) had a higher proportion of experiencing an increase in diastolic blood pressure compared to those exposed to 85 dB or less (83.3%). This difference is statistically significant (p-value = 0.0010).

Table 5. Relationship between noise intensity and increased diastolic blood pressure

Noise intensity	Increase in diastolic blood pressure				p	RP	95%CI	
	Not increase		Increase					
	n	%	n	%			Lower	Upper
≤ 85 dB	10	83.3	2	16.7	0.001	3.75	1.524	9.229
> 85 dB	4	22.2	14	77.8				

The statistical analysis demonstrated a significant difference ($p < 0.05$) between pre-work and post-work systolic and diastolic blood pressure measurements. Specifically, the mean systolic blood pressure was found to be 5.60 mmHg greater before work, a difference that was statistically significant ($p = 0.001$). Likewise, the mean diastolic blood pressure was 4.27 mmHg higher before work, which was also statistically significant ($p = 0.018$). These results suggest a consistent pattern of decreasing blood pressure values from the pre-work to the post-work period.

Table 6. t test results

Variable	Paired differences			
	Mean	SD	t	p
Pre-work systolic blood pressure - post-work systolic blood pressure	-5.600	8.516	-3.602	0.001
Pre-work diastolic blood pressure - post-work diastolic blood pressure	-4.267	9.296	-2.514	0.018

Discussion

Descriptive analysis indicated a trend toward increased systolic blood pressure in the group exposed to higher noise levels. However, chi-square tests did not support this finding statistically. Similarly, Stefani et al[10], employing both chi-square and paired t-tests, concluded that there was no significant association

between noise intensity and increased systolic blood pressure (p= 0.375). This study hypothesizes that noise exposure of 81.7 dB in the workplace can impact workers' health, although it may not pose a very serious risk. The detrimental effects of noise are influenced by several factors, including noise intensity, duration of exposure, and the high and low frequencies of the compressor sound. According to the Indonesian Ministerial Regulation Number 5 of 2018, the safe noise threshold in the workplace is 85 dB for 8 hours per day and 40 hours per week. Exceeding this threshold can have adverse effects on workers' health.

Previous research[11] demonstrated a correlation between noise intensity and increases in systolic and diastolic blood pressure. This elevation in blood pressure is triggered by increased stress due to noise, which impacts cardiac output. Increased cardiac output, in turn, leads to higher systolic blood pressure. The results of this study indicate that the workers examined did not experience an increase in systolic blood pressure. This is likely due to the relatively low intensity of work activities, which did not place an excessive burden on the heart and did not affect cardiac output.

This research has revealed a significant association between noise intensity and diastolic blood pressure. Specifically, individuals exposed to noise levels exceeding 85 dB are more likely to experience an increase in diastolic blood pressure compared to those exposed to lower noise levels. Noise exposure in the workplace exceeding 92-102 dB was found to have a significant impact on workers' health, particularly on blood pressure. Research results showed a positive correlation between the duration of noise exposure and increased blood pressure. The majority of workers in this study had more than two decades of work experience and worked 8-12 hours per day. Long-term exposure to high-intensity noise is suspected to trigger the body's stress response, characterized by an increase in stress hormones, leading to emotional instability. This condition then triggers an increase in cardiac output and blood pressure. In addition to workplace factors, unhealthy lifestyles such as smoking also contributed to increased blood pressure in this group of workers.

Conclusion

Noise level measurements at the research site exhibited significant variability, with a maximum of 102 dB recorded in Unit III and a minimum of 81.7 dB in Unit I. Analysis of the correlation between noise intensity and blood pressure yielded intriguing results. While no significant association was found between noise intensity and elevated systolic blood pressure ($p = 0.317$; RP = 2.250; 95% CI = 0.373 – 19.060), a significant correlation emerged between noise intensity and increased diastolic blood pressure ($p = 0.001$; RP = 3.750; 95% CI = 1.524 – 9.229). Paired t-tests revealed a significant difference in both systolic and diastolic blood pressure before and after work shifts (systolic: Mean = -5.600; SD = 8.516; $t = -3.602$; $p = 0.001$; diastolic: Mean = -4.267; SD = 9.296; $t = -2.541$; $p = 0.018$).

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