



THE EFFECT OF OCCUPATIONAL ENVIRONMENTAL FACTORS ON ELEVATED BLOOD PRESSURE AMONG WORKERS IN A PALM OIL MILL: A CASE STUDY AT PT. X, LANGKAT REGENCY

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Abstract

Occupational diseases remain a critical concern in occupational health, particularly in industrial environments with high exposure to environmental hazards. This study aimed to analyze the effect of occupational environmental factors specifically noise and vibration exposure on elevated blood pressure among workers at a palm oil mill at PT. X in Langkat Regency. An analytical observational study with a cross-sectional design was conducted, involving all 79 male production workers selected through total sampling. Data were collected using structured

questionnaires, direct blood pressure measurements, and assessments of noise and vibration exposure levels. Statistical analysis was performed using the chi-square test and multivariate logistic regression at a 95% confidence level ($p \leq 0.05$). The findings revealed that 50.6% of workers had hypertension, and 83.5% were exposed to noise levels exceeding the permissible threshold (>85 dB). A statistically significant association was found between noise exposure and hypertension ($p=0.013$; $OR=7.090$; 95% $CI: 1.435-35.033$), indicating that high noise exposure increased the risk of elevated blood pressure by sevenfold. Conversely, vibration exposure was not significantly associated with hypertension ($p=0.179$), likely due to the fact that 86.1% of workers were exposed to vibration levels within safe limits (<0.8661 m/s²). These results underscore noise as a modifiable risk factor for hypertension, necessitating immediate preventive action. Recommendations include the implementation of engineering controls, provision of personal protective equipment, routine noise monitoring, and strict adherence to national occupational health regulations. Controlling noise exposure in palm oil processing facilities is essential to protect cardiovascular health and enhance worker productivity.

Keywords: Hypertension, Noise, Occupational Environment, Vibration

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INTRODUCTION

The rapid industrial development in Indonesia has led to a significant increase in the number of workers (Mauliya & Putra, 2022). This surge in industrialization is closely associated with advancements in modern technology. However, technological improvements often come with side effects that must be acknowledged and managed (Yulianto, 2022). Many companies and industries tend to prioritize production processes over the management of human resources (Muharani & Dameria, 2019). Consequently, industries often overlook the potential adverse health impacts associated with the technologies they employ (Yandoyo & Merijanti, 2019). Palm oil mills, as part of the agro-industrial sector, present various occupational hazards stemming from physical, chemical, biological, ergonomic, and psychosocial risk factor (Ismayaton, 2020). These facilities comprise several operational stations including the weighing station, loading ramp, sterilizer station, thresher station, press station, clarification station, kernel station, engine room, boiler, and water treatment plant (Masruroh & Mardesci, 2021); (Tasyania et al., 2022).

As industrialization progresses, the establishment of diverse workplaces brings with it greater occupational hazards due to the use of increasingly sophisticated and complex machinery and equipment (Herdiningtyas et al., 2017). Although these technologies enhance production efficiency and facilitate workers' tasks, they also pose significant risks, including occupational accidents and diseases (Gunara, 2021); (Zhang et al., 2022).

Occupational diseases (ODs) can result from multiple factors, with the work environment being a critical contributor (Nieto-Alvarez et al., 2022). Diseases often arise from multifactorial causes, in which the nature of work and the occupational setting play a substantial role (Suma'mur, 2014). A healthy and safe working environment promotes worker well-being, whereas suboptimal working conditions can lead to increased blood pressure and the development of hypertension. According to the World Health Organization (WHO) in 2023, hypertension is diagnosed when systolic blood pressure is ≥ 140 mmHg and/or diastolic blood pressure is ≥ 90 mmHg, measured on more than one occasion (World Health Organization (WHO), 2023).

According to the World Health Organization in 2015, approximately 1.13 billion people worldwide suffer from hypertension, indicating that one in three individuals is diagnosed with the condition. The number of people affected by hypertension continues to rise annually, with projections estimating that by 2025, 1.5 billion individuals will be hypertensive, and approximately 9.4 million deaths each year will be attributable to hypertension and its complications (Ministry of Health, Republic of Indonesia, 2019) (Kementerian Kesehatan Republik Indonesia, 2019).

Globally, an estimated 1.28 billion adults aged 30–79 years are living with hypertension, with nearly two-thirds residing in low- and middle-income countries. Alarmingly, about 46% of adults with hypertension are unaware of their condition (WHO, 2023). In Indonesia, The 2018



Basic Health Research in 2018 reported a hypertension prevalence of 34.1% among individuals aged ≥ 18 years, accounting for approximately 658,201 cases. This represents an increase from the 2013 prevalence rate of 25.8%. However, it is estimated that only one-third of hypertension cases in Indonesia are diagnosed, with the remaining two-thirds going undetected.

In North Sumatra, the 2018 hypertension prevalence based on physician diagnosis among adults (≥ 18 years) was 5.52% (41,382 cases), while measurements indicated a prevalence of 29.19% (41,131 cases) (Risksdas Sumut, 2018). Furthermore, data from the Medan City Health Office (2019) revealed that 38,556 individuals were diagnosed with hypertension across 41 public health centers.

Among various contributing factors, occupational environmental conditions particularly exposure to noise and vibration play a significant role in the development of hypertension (Nieto-Alvarez et al., 2022). Noise has been identified as a major occupational risk factor that can elevate blood pressure and must be urgently addressed. Workers exposed to excessive noise often experience emotional instability, which can increase stress levels (Zhou et al., 2022). Prolonged stress stimulates the overproduction of stress hormones such as adrenaline and cortisol, which leads to vasoconstriction and forces the heart to pump harder over time, ultimately resulting in elevated blood pressure. Therefore, effective noise control is imperative in occupational settings (Pretzsch et al., 2021).

A study by (Indriyanti et al., 2019), found that workplace noise exposure significantly increased the risk of elevated blood pressure. Their findings demonstrated that noise levels exceeding the threshold limit of 85 dB significantly increased the risk of hypertension among workers.

In addition to noise, vibration exposure has also been shown to increase heart rate, blood pressure, tidal volume, respiratory rate, and may lead to hyperventilation (Fitria et al., 2023). Research conducted by (Alfira et al., 2023) revealed a significant association between combined noise and vibration exposure and changes in both systolic and diastolic blood pressure. The study, conducted at a distance of 12 meters from a railway track, reported a noise level of 100.45 dBA and vibration exposure at a frequency of 63 Hz with an amplitude of 6.69 μ .

A preliminary survey conducted at the palm oil mill of PT. X, Langkat Regency identified physical occupational hazards, particularly noise and vibration. Noise level measurements at the facility revealed a value of 91 decibels (dBA), which exceeds the permissible exposure limit, especially considering that workers are engaged in an 8-hour work shift. To assess potential health impacts, blood pressure measurements were carried out on 20 workers. The results indicated that 40% of the workers had blood pressure readings above 140/90 mmHg, while the remaining 60% had values below this threshold.



If left unmanaged, elevated blood pressure may lead to severe health complications such as stroke, heart disease, and other cardiovascular disorders, ultimately affecting worker productivity. At PT. X, Langkat Regency, operational activities involve the use of machinery and equipment capable of generating substantial noise and vibration. The noise levels recorded during the assessment confirmed that they exceeded the acceptable threshold, underscoring noise exposure as a key contributor to increased blood pressure. In addition to noise and vibration, other contributing factors to elevated blood pressure include age, length of employment, daily exposure duration, smoking habits, salt intake, coffee consumption, and other lifestyle-related variables. Given these findings, this study aims to investigate the factors associated with elevated blood pressure among palm oil mill workers at PT. X, Bahorok Subdistrict, Langkat Regency.

METHODS

Study Design, Research Location and Period, Population and Sample

This study employed an observational analytic design using a cross-sectional approach. The research was conducted at PT. X, located in Langkat Regency, from August to October 2024. The study population included all workers in the Production Department of the Palm Oil Mill at PT. X in Bahorok Subdistrict, totaling 79 individuals. A total sampling technique was applied; thus, the entire population was included as the study sample, consisting of 79 male workers.

Measurement Tools, Data Collection, and Data Analysis

Data collection involved the use of a structured questionnaire to gather respondent identity information and a measurement form for each study variable. Noise and vibration measurements were conducted by certified technicians from the Occupational Health and Safety Center (Balai K3) in Medan. Noise levels were measured using a Sound Level Meter, vibration was measured using a Vibration Meter, and blood pressure was assessed using a digital sphygmomanometer.

The dependent variable was blood pressure status (categorized as normotensive or hypertensive), while the independent variables were noise and vibration exposure, both measured on ordinal scales. Data analysis was performed using SPSS version 25. The analytical process involved three stages: (1) univariate analysis using descriptive statistics and frequency distributions; (2) bivariate analysis using the chi-square test to determine the relationship between each independent variable and the dependent variable, with a significance threshold of $p < 0.25$ for inclusion in multivariate analysis; and (3) multivariate analysis using multiple logistic regression to identify factors significantly associated with elevated blood pressure among palm oil mill workers at PT. X, with a significance level of 95% ($p \leq 0.05$).



The Acceptable Threshold Value for Noise and Vibration

The acceptable threshold for noise exposure was set at 85 dBA, in accordance with the Regulation of the Minister of Manpower of the Republic of Indonesia No. 5 of 2018. The threshold for vibration exposure was 0.8661 m/s², based on the Regulation of the Minister of Health of the Republic of Indonesia No. 5 of 2018.

Ethical Consideration

This study obtained ethical approval from the Health Research Ethics Committee of Universitas Sumatera Utara (Approval No.: ____ /KEPK/USU/2024). In addition, permission was obtained from academic administrators and relevant authorities prior to data collection. All participants provided informed consent before completing the questionnaire.

RESULTS

High Blood Pressure (Hypertension)

Based on the results of blood pressure measurements among workers at the Palm Oil Mill of PT. X in Langkat Regency, the distribution of hypertension cases is presented in the following table:

Table 1. Frequency Distribution of Hypertension among Workers at the Palm Oil Mill of PT. X, Langkat Regency

Blood Pressure Status	n	%
Hypertensive	40	50.6
Normotensive	39	49.4
Total	79	100.0

As shown in Table 1, out of 79 workers, 40 individuals (50.6%) were classified as hypertensive, while 39 individuals (49.4%) were found to have normal blood pressure. These findings indicate that more than half of the production workers at PT. X exhibited elevated blood pressure, suggesting a substantial prevalence of hypertension in this occupational setting.

Environmental Factors

Based on the environmental measurements of noise and vibration levels in the workplace at the Palm Oil Mill of PT. X, Langkat Regency, the frequency distribution of environmental exposure is presented as follows:



Table 2. Frequency Distribution of Environmental Factors at the Palm Oil Mill of PT. X, Langkat Regency

Environmental Factors	n	%
Noise		
> 85 dB (Above Threshold Limit)	66	83.5
< 85 dB (Below Threshold Limit)	13	16.5
Vibration		
> 0,8661 m/det ² (Above Threshold Limit)	11	13.9
< 0,8661 m/det ² (Below Threshold Limit)	68	86.1

As shown in Table 2, the majority of workers (83.5%) were exposed to noise levels exceeding the permissible threshold of 85 dB, while only 16.5% worked in environments with noise levels within acceptable limits. Regarding vibration exposure, 13.9% of workers were exposed to levels above the threshold value of 0.8661 m/s², whereas 86.1% were exposed to vibration levels considered within safe limits. These findings highlight significant environmental risks, particularly in relation to excessive occupational noise.

Association Between Environmental Factors and High Blood Pressure

The analysis of the association between environmental factors and high blood pressure among workers at the Palm Oil Mill of PT. X in Langkat Regency is presented in the table below:

Table 3. Association Between Environmental Factors and High Blood Pressure Among Palm Oil Mill Workers at PT. X, Langkat Regency

Environmental Factors	High Blood Pressure				RP	Pvalue
	Hypertension		Normotension			
	n	%	n	%		
Noise						
> 85 dB	38	57.6	28	42.4	3.742	0.013
≤ 85 dB	2	15.4	11	84.6		
Vibration						
> 0,8661 m/det ²	3	27.3	8	72.7	0.501	0.179
< 0.8661 m/det ²	37	54.4	31	45.6		

As shown in Table 3, the statistical test revealed a significant association between occupational noise exposure and high blood pressure, with a p-value of 0.013 ($p < 0.05$). The calculated relative risk (RP) was 3.742, indicating that workers exposed to noise levels above 85 dB had approximately 4 times the risk of developing hypertension compared to those exposed to lower noise levels. Conversely, the association between occupational vibration exposure and high



blood pressure was not statistically significant, with a p-value of 0.179 ($p > 0.05$). This suggests that, within this study population, vibration exposure was not significantly associated with elevated blood pressure among workers at the Palm Oil Mill of PT. X in Langkat Regency.

Factors Affecting High Blood Pressure Among Palm Oil Mill Workers at PT. X, Langkat Regency

The analysis of factors influencing high blood pressure among palm oil mill workers at PT. X in Langkat Regency is presented in the following table:

Table 4. Factors Affecting High Blood Pressure Among Palm Oil Mill Workers at PT. X, Langkat Regency

Variable	β	Exp B	Confidence Interval (95% CI) for Exp B		Pvalue
			Lower	Upper	
Noise	1.959	7.090	1.435	35.033	0.016
Vibration	-1.060	0.346	0.080	1.506	0.157

Based on Table 4, the multivariate analysis indicates that noise exposure significantly affects the likelihood of developing high blood pressure among palm oil mill workers. The adjusted odds ratio (Exp(B)) was 7.090, suggesting that workers exposed to excessive noise levels are approximately seven times more likely to experience elevated blood pressure compared to those exposed to noise below the threshold. This association was statistically significant ($p = 0.016$), confirming a strong influence of noise exposure on the risk of hypertension in the workplace.

In contrast, vibration exposure was not significantly associated with high blood pressure (Exp(B) = 0.346; $p = 0.157$). This indicates that vibration did not show a meaningful impact on blood pressure levels among workers in this study population.

DISCUSSION

The Effect of Noise Exposure on High Blood Pressure Among Palm Oil Mill Workers at PT. X, Langkat Regency

Noise is defined as unwanted or disruptive sound originating from production processes in the workplace, measured in decibels (dBA) (Ministry of Manpower Regulation No. 5 of 2018). It is a common occupational hazard and is considered excessive when it exceeds the permissible exposure limit (PEL) of 85 dBA for 8 hours per day or 40 hours per week (Herdiningtyas et al., 2017). The noise levels in the work environment of the palm oil mill at PT. X, Langkat Regency, were found to be significantly above the threshold, posing a risk to workers' health.



This study found that 66 workers (83.5%) were exposed to noise levels above the threshold (>85 dBA), while 13 workers (16.5%) were exposed to noise levels at or below the threshold (≤ 85 dBA). High levels of noise exposure were associated with increased blood pressure among the workers. Statistical analysis confirmed a significant association between occupational noise and high blood pressure ($p = 0.016$), suggesting that excessive noise exposure activates hormonal and autonomic nervous system responses, increasing heart rate and primarily affecting systolic blood pressure. The regulatory system attempts to normalize this change, which may result in a smaller increase in diastolic pressure compared to systolic pressure.

Additionally, chronic noise exposure may lead to emotional instability and increased stress levels (Luthfiyah & Widajati, 2019); (Az-Zahra et al., 2024). Prolonged stress can cause vasoconstriction and elevate heart rate, leading to increased blood pressure (Indriyanti et al., 2019); (Midu & Astrid, 2024). This occurs through the release of stress hormones such as adrenaline and cortisol, which induce vasoconstriction and stimulate cardiac output (Fitria et al., 2023). Repeated stress episodes can lead to sustained hypertension (Septiasary et al., 2024).

The main sources of noise at PT. X were identified as industrial machinery such as generators, compressors, metal contact tools, and equipment operating continuously at high volume. According to the Ministry of Manpower Regulation No. 5 of 2018, the maximum permissible noise level is 85 dBA for an 8-hour workday.

The findings of this study are consistent with Indriyanti et al. (2019), who found that occupational noise exposure significantly increased the risk of hypertension ($p = 0.001$). Workers exposed to noise levels above 85 dBA had a 19.8 times higher risk of developing hypertension compared to those exposed to lower levels. Similarly, another study on workers at PT. X's Circular Loom Unit demonstrated a significant positive correlation between noise intensity and systolic blood pressure ($p=0.018$; $\rho=0.478$), and between noise and diastolic pressure ($p=0.045$; $\rho=0.413$), indicating that higher noise levels correspond to elevated systolic and diastolic pressures (Luthfiyah & Widajati, 2019).

The Effect of Vibration Exposure on High Blood Pressure Among Palm Oil Mill Workers at PT. X, Langkat Regency

Vibration is the oscillatory motion of an object or particle around a point of equilibrium, which may affect workers' health if it exceeds the established threshold. According to the Indonesian Ministry of Health Regulation No. 5 of 2018, the Permissible Exposure Limit (PEL) for vibration is 0.8661 m/s^2 . Workplace vibration can originate from production machinery, mobile equipment, and operational activities involving vibrating tools.



This study found that 11 workers (13.9%) were exposed to vibration levels above the threshold ($> 0.8661 \text{ m/s}^2$), while 68 workers (86.1%) were exposed to levels at or below the threshold ($\leq 0.8661 \text{ m/s}^2$). This distribution indicates that the majority of workers (86.1%) were operating in environments with vibration levels considered to be within safe limits.

The statistical analysis revealed no significant effect of vibration on elevated blood pressure or hypertension among workers at PT. X ($p = 0.157$; $p > 0.05$). This may be attributed to the fact that most workers were exposed to vibration levels below the threshold, which likely did not reach the intensity required to significantly affect the cardiovascular system.

Additionally, the duration of exposure may not have been sufficient to induce meaningful physiological changes in blood pressure. Although vibration can influence the autonomic nervous system and stimulate sympathetic activity, potentially elevating blood pressure, the relatively low intensity and limited duration of vibration exposure in this study did not produce a statistically significant effect (Łastowiecka-Moras, 2025).

These findings are consistent with previous studies indicating that the impact of vibration on blood pressure is highly dependent on exposure intensity, duration, and type of vibration (Bartel & Mosabbir, 2021). (Salam et al., 2024) demonstrated that cardiovascular effects become more evident under conditions of high-intensity and long-term exposure. Similarly, (Khan & Burdzik, 2023) reported that low-to-moderate intensity vibration did not result in significant changes in workers' blood pressure.

Conversely, the findings differ from those of (Alfira et al., 2023), who reported that railway vibration contributed to subjective complaints among residents, with 63.6% reporting symptoms. Another study on furniture workers found a mean hand-arm vibration exposure of 34.25 m/s^2 , far exceeding the recommended limit. Pearson and Spearman correlation tests revealed a significant association between vibration exposure and smoking habits with subjective complaints (Stjernbrandt et al., 2024).

Despite the lack of a statistically significant effect in the current study, primary preventive measures to control vibration exposure in the workplace remain essential. Long-term exposure to vibration can result in adverse health outcomes such as musculoskeletal disorders, peripheral circulatory impairment, and neurological disturbances.

CONCLUSION AND RECOMMENDATION

Conclusion

This study concludes that the prevalence of hypertension among workers at PT. X Palm Oil Mill in Langkat Regency is notably high, with 50.6% diagnosed with elevated blood pressure. A substantial proportion of workers (83.5%, $n=66$) were exposed to noise levels exceeding the



permissible exposure limit (>85 dB), whereas only 13.9% ($n=11$) experienced vibration levels above the established threshold (>0.8661 m/s²), indicating effective vibration control measures in place.

Occupational noise exposure was found to have a statistically significant association with hypertension ($p=0.013$; $p<0.05$), where workers exposed to noise levels >85 dB had a 7.090 times higher risk of developing hypertension (OR = 7.090, 95% CI: 1.435–35.033). Conversely, vibration exposure did not show a significant association with hypertension ($p = 0.179$; $p > 0.05$), likely due to the majority of workers (86.1%) operating within vibration exposure levels considered safe.

These findings affirm that workplace noise exposure is a modifiable risk factor for hypertension in industrial settings, particularly in palm oil processing facilities where continuous mechanical operations generate high-decibel environments.

Recommendations

It is recommended that PT. X Palm Oil Mill in Langkat Regency implement comprehensive noise control interventions. These include engineering controls such as equipment enclosures, installation of sound-absorbing barriers, and routine machinery maintenance. The company should also establish a mandatory hearing conservation program involving the distribution of appropriate personal protective equipment (PPE), compliance monitoring, and quarterly noise level assessments at all workstations to ensure continuous surveillance. Furthermore, PT. X Palm Oil Mill in Langkat Regency should ensure full compliance with the Indonesian Ministry of Manpower Regulation No. 5 of 2018 regarding occupational noise exposure limits. The implementation of a work rotation schedule is advisable to reduce the duration of individual exposure to high-noise areas. Additionally, optimizing facility layout to spatially separate high noise zones from primary worker pathways can further minimize exposure risk.



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