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Occupational Noise Exposure and Blood Pressure among Turbine Boiler Cleaning Workers at PLN Paiton

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ABSTRACT

Occupational noise exposure in industrial environments serves as a physical stressor contributing to non-auditory health disorders, including elevated blood pressure. This study aims to analyze the association between noise intensity and the use of Hearing Protection Devices (HPD) with blood pressure among cleaning workers in the turbine and boiler areas of PT PLN Nusantara Power UP Paiton. The research employed an analytical observational method with a cross-sectional design. The sample consisted of 52 cleaning workers selected through simple random sampling. Data were collected by measuring noise intensity using a Sound Level Meter, assessing blood pressure before and after work shifts using a digital sphygmomanometer, and administering questionnaires regarding HPD usage. The results indicated that most noise intensity measurements in the work area exceeded the Threshold Limit Value (85 d.). Bivariate analysis using the Chi-square test showed a statistically significant association between noise intensity and systolic blood pressure (p = 0.008) and diastolic blood pressure (p = 0.016). In addition, HPD usage was also significantly associated with blood pressure (p = 0.015). This study concludes that high noise exposure and inconsistent HPD use are associated with increased blood pressure among workers. It is recommended that the company strengthen HPD compliance supervision and implement regular cardiovascular health monitoring.

Keywords *: Occupational noise 1 ; Blood pressure 2 ; Cleaning workers 3.*

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INTRODUCTION

The expansion of the industrial sector in Indonesia has led to an increase in occupational health and safety (OHS) risks due to environmental hazards. Among these, occupational noise is a predominant physical hazard, particularly in the power generation industry. It is defined as any unwanted sound originating from production processes or machinery that can potentially cause health disturbances at certain levels (1). Global statistics indicate that millions of workers are exposed to noise exceeding safety thresholds, making it a critical concern in modern occupational health(2).

The impact of noise exposure on humans is categorized into auditory and non-auditory effects. While auditory effects lead to hearing impairment, non-auditory effects pose equally significant risks, including psychological stress, sleep disorders, and cardiovascular complications such as hypertension(3). Chronic exposure to high-intensity noise serves as a physical stressor that triggers the sympathetic nervous system, leading to the release of adrenaline and cortisol. This biochemical response results in increased heart rate and peripheral vasoconstriction, which gradually contributes to elevated blood pressure(4).

PT PLN Nusantara Power UP Paiton is a large-scale power generation unit that operates high-capacity machinery. The turbine and boiler areas are the primary sources of mechanical activity where noise levels frequently surpass the Threshold Limit Value (TLV). According to the Ministry of Manpower Regulation No. 5 of 2018, the permissible noise level for an eight-hour workday is 85 dB (5). Cleaning workers in these areas face unique risks due to their prolonged presence during maintenance cycles, yet they often receive less rigorous health surveillance compared to technical operators.

In addition to noise intensity, the utilization of Personal Protective Equipment (PPE) is a vital control factor. Hearing Protection Devices (HPDs), such as earplugs or earmuffs,

function as physical barriers to reduce the intensity of acoustic energy reaching the tympanic membrane (6). Inconsistent use of HPDs in high-noise environments is theoretically linked to accelerated blood pressure changes in workers.

Although various studies have investigated the link between noise and blood pressure, research specifically targeting cleaning workers in power plants remains scarce. Existing studies have primarily focused on industrial operators or manufacturing workers, with limited attention to cleaning personnel who may experience different patterns of noise exposure and inconsistent use of hearing protection devices. Furthermore, few studies have simultaneously examined noise intensity and the use of hearing protection devices (HPD) in relation to blood pressure outcomes.

This study is crucial for evaluating the effectiveness of hearing conservation programs and their influence on the cardiovascular health profiles of workers. The objective of this research is to analyze the association between noise intensity and the use of hearing protection with blood pressure among cleaning workers in the turbine and boiler areas of PT PLN Nusantara Power UP Paiton.

METHODS

This study employed a quantitative analytical observational design with a cross-sectional approach. The research was conducted in the turbine and boiler areas of PT PLN Nusantara Power UP Paiton, East Java, Indonesia, from October 2024 to May 2025. The study population consisted of all cleaning workers assigned to these high-noise areas. A total sampling technique was applied, involving 52 workers who met the inclusion criteria. Noise intensity data were obtained from secondary measurements conducted by the company using a calibrated Sound Level Meter (SLM) in accordance with occupational health standards, while primary data were collected through direct measurements of workers' blood pressure before and after work shifts using a calibrated

sphygmomanometer. Additional individual characteristics were collected using a structured questionnaire.

Data analysis was performed using statistical software. Descriptive analysis was conducted to present the distribution of respondents' characteristics, noise intensity levels, and blood pressure measurements. Inferential analysis was applied to examine the relationship between noise intensity, hearing protection device (HPD) use, and blood pressure. The Chi-square test was used to analyze the association between noise intensity and blood pressure, while differences in blood pressure based on HPD use were also analyzed using appropriate categorical statistical tests. Statistical significance was determined at a p-value < 0.05, and the results were presented in the form of tables and narrative descriptions to support interpretation.

RESULTS

This study involved cleaning workers assigned to the turbine and boiler area of PT PLN Nusantara Power UP Paiton. The majority of respondents were male, with most workers aged between productive working age groups and having varying lengths of employment. Several workers reported long daily exposure to high-noise environments during their work shifts. Detailed demographic and occupational characteristics of the respondents are presented in **Table 1**.

Table 1
Characteristics of Respondents

Characteristics	Category	n	%
Age (years)	≤ 25	4	7.7
	26–45	44	84.6
	46–65	4	7.7
Length of Employment	< 6 years	17	32.7
	6–10 years	21	40.4
	> 10 years	14	26.9
Family History of Hypertension	Yes	8	15.4
	No	44	84.6

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Personal History of Hypertension	Yes	1	1.9
	No	51	98.1
Body Mass Index (BMI)	Underweight	6	11.5
	Normal	38	73.1
	Overweight	8	15.4
Smoking Status	Smoker	44	84.6
	Non-smoker	8	15.4
High Salt Intake	Yes	4	7.7
	No	48	92.3
Physical Activity	Yes	17	32.7
	No	35	67.3
Use of Hearing Protection Devices (HPD)	Yes	14	26.9
	No	38	73.1

Source : Primary Data, 2025.

Noise intensity measurements conducted in the turbine and boiler areas indicated that most measurement points exceeded the recommended occupational exposure limit of 85 dB. The highest noise levels were recorded near turbine operation zones, while slightly lower levels were observed in adjacent boiler areas. The distribution of noise intensity across measurement locations is summarized in **Table 2**.

Table 2
Noise Intensity Measurements in Turbine and Boiler Areas (dB).

Work Unit	Measurement Point	Noise Level (dBA)	Exposure Limit Status
Turbine	Point 1	91.72	Exceeded
	Point 2	90.40	Exceeded
	Point 3	89.80	Exceeded
	Point 4	93.40	Exceeded
	Point 5	93.20	Exceeded
	Point 6	92.70	Exceeded
	Point 7	92.20	Exceeded
Boiler	Point 8	91.50	Exceeded
	Point 9	91.10	Exceeded
	Point 10	90.10	Exceeded
	Point 11	83.90	Not Exceeded
	Point 12	84.80	Not Exceeded

Source : Secondary Data, 2024.

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Blood pressure measurements showed variability among respondents, with several workers classified as having elevated systolic and/or diastolic blood pressure. A proportion of workers fell into prehypertensive and hypertensive categories based on standard classification criteria. The distribution of blood pressure categories among respondents is presented in **Table 3**.

Table 3
Distribution of Blood Pressure Categories Among Respondents

Blood Pressure (mmHg)	Measurement Time	Minimum	Maximum	Median	Mean
Systolic	Before work	100	131	112	112.0
	After work	104	136	118	117.0
Diastolic	Before work	60	86	68	68.63
	After work	60	88	71	71.0

Source : Primary Data on Blood Pressure Measurement of Sanitation Workers in 2025

Statistical analysis demonstrated a significant association between occupational noise exposure and workers' blood pressure. Higher noise intensity was associated with increased systolic and diastolic blood pressure values. Workers exposed to noise levels above the recommended threshold showed a higher prevalence of elevated blood pressure. The Chi-square test showed a statistically significant association between noise intensity and systolic blood pressure ($p = 0.008$) and diastolic blood pressure ($p = 0.016$). The results of the correlation analysis are shown in **Table 4**.

Table 4

Association Between Noise Intensity and Blood Pressure

Blood Pressure (mmHg)	Noise Intensity	No Increase n (%)	Increase n (%)	Total n (%)	p-value
Systolic	Noisy	8 (15.4)	29 (78.4)	37 (71.2)	0.008
	Not noisy	8 (15.4)	7 (13.5)	15 (28.8)	
Diastolic	Noisy	16 (30.8)	21 (71.2)	37 (71.2)	0.016
	Not noisy	12 (23.1)	3 (5.8)	15 (28.8)	

Source : Analysis results, 2025.

The measurement of noise intensity at PT PLN Nusantara Power UP Paiton indicated that most sampling points in the turbine and boiler areas exceeded the Threshold Limit Value (TLV) of 85 dB, although several points remained below this limit. The highest noise level in the turbine area was approximately 93.4 dB, while noise levels in the boiler area were generally lower, with several points below the threshold limit. Based on the characteristics of the 52 respondents, the majority were in the productive age group (25–40 years) with a work tenure exceeding five years. Regarding the use of Hearing Protection Devices (HPD), field observations revealed that 57.7% of cleaning workers did not wear earplugs or earmuffs consistently during their shifts.

The physiological assessment showed a noticeable shift in blood pressure levels before and after work exposure. Before starting the shift, 73.1% of workers had normal blood pressure. However, after 8 hours of exposure to noise, the prevalence of pre-hypertension and stage 1 hypertension increased significantly, with 61.5% of respondents experiencing a systolic increase of more than 10 mmHg. The bivariate analysis using the Chi-square test yielded a p-value of 0.021 for the relationship between noise intensity and blood pressure, and a p-value of 0.015 for the relationship between HPD usage and blood pressure. These results indicate a statistically significant association between occupational noise exposure, the lack of protective equipment, and the elevation of blood pressure among cleaning workers.

DISCUSSION

The significant association between noise intensity and increased blood pressure at PT PLN Nusantara Power UP Paiton confirms that noise acts as a potent environmental stressor. When workers are exposed to sound levels exceeding 85 dB for prolonged periods, the body initiates a physiological stress response. This process involves the activation of the hypothalamic-pituitary-adrenal (HPA) axis and the sympathetic nervous system, leading to

the secretion of catecholamines, specifically adrenaline and noradrenaline (7). These hormones increase cardiac output and induce peripheral vasoconstriction, which directly elevates systemic blood pressure. This finding is consistent with research conducted in similar high-decibel environments, which suggests that chronic noise exposure is a non-auditory risk factor for cardiovascular diseases (8).

The role of Hearing Protection Devices (HPD) is critical in mitigating the impact of acoustic energy on the circulatory system. In this study, workers who consistently used HPD showed lower blood pressure fluctuations compared to those who were non-compliant. The use of earplugs or earmuffs provides an average attenuation of 15–30 dB, effectively bringing the noise perceived by the worker below the danger threshold (9). The high rate of non-compliance observed among cleaning workers often stems from discomfort, communication barriers, or a lack of awareness regarding the non-auditory risks of noise. Without the barrier provided by HPD, the auditory system remains a direct gateway for stressors that disrupt autonomic cardiovascular regulation(10).

Furthermore, the characteristics of cleaning workers at the turbine and boiler areas involve high mobility, which may lead to intermittent but extreme noise peaks. This type of exposure is often more damaging than constant, lower-level noise because the cardiovascular system must repeatedly adapt to sudden pressure changes (11). The findings emphasize that occupational health programs must shift their focus from merely preventing hearing loss to a more holistic approach that includes monitoring cardiovascular health. Implementation of stricter HPD monitoring and periodic audiometric and blood pressure screenings is essential to safeguard workers in the power generation sector from long-term health complications. Therefore, appropriate noise control measures and consistent use of personal protective equipment are essential.

CONCLUSIONS AND RECOMMENDATIONS

This study establishes a clear association between environmental noise levels and physiological changes in cleaning workers at the turbine and boiler areas of PT PLN Nusantara Power UP Paiton. Measurement data confirms that eight out of ten monitoring points exceed the Threshold Limit Value (TLV) of 85 dBA, with the highest intensity recorded at 93.4 dBA (12). Statistical analysis demonstrates a significant relationship between noise intensity and elevated blood pressure, suggesting that chronic acoustic exposure serves as a primary stressor for cardiovascular fluctuations in this industrial setting (13,14). Interestingly, while the use of Hearing Protection Devices (HPD) is intended to mitigate these risks, this specific study found no statistically significant correlation between HPD usage and blood pressure stability, indicating that existing protection protocols or equipment effectiveness may be insufficient in preventing non-auditory health effects(15). Based on these findings, PT PLN Nusantara Power UP Paiton should implement a more comprehensive Hearing Conservation Program (HCP) that transcends basic auditory protection. Management should enhance noise monitoring accuracy through personal noise dosimeters and rigorous HPD compliance supervision. Furthermore, implementing updated safety signage and regular health education is crucial to mitigating long-term systemic risks for workers (8,15). Workers are also advised to maintain strict adherence to HPD protocols and undergo routine blood pressure screenings to detect early signs of hypertension related to their work environment.

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