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THE ASSOCIATION BETWEEN OCCUPATIONAL NOISE EXPOSURE AND THE INCIDENCE OF HYPERTENSION AMONG INDUSTRIAL WORKERS

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ABSTRACT

The Association Between Occupational Noise Exposure And The Incidence Of Hypertension Among Industrial Workers. *One common form of pollution is noise exposure, which, when exceeding the threshold of 85 dB(A), may increase the risk of hypertension. Hypertension is defined as systolic blood pressure ≥140 mmHg and/or diastolic blood pressure ≥90 mmHg, with several risk factors including age, length of employment, smoking habits, sleep duration, obesity, and diabetes. This study aimed to analyze the risk factors of hypertension among workers in the wood furniture industry. An observational analytic study with a cross-sectional approach was conducted involving 100 male workers selected through purposive sampling. Statistical analysis was performed using the chi-square test. The highest measured noise intensity was 95.3 dB(A), with an average of 87.3 dB(A). The mean systolic and diastolic blood pressures were 127.5 mmHg and 82 mmHg, respectively. Bivariate analysis showed that noise intensity (p = 0.021; PR = 3.619) and obesity (p = 0.005; PR = 4.334) were significantly associated with the incidence of hypertension. It can be concluded that high noise exposure and obesity are risk factors for hypertension among wood furniture industry workers.*

INTRODUCTION

The rapid development of industry in Indonesia has brought both positive and negative impacts on society. One of the negative impacts of industrialization is noise pollution[1]. In the wood furniture industry, this pollution manifests as high noise intensity. Industrial noise is often intermittent and can adversely affect workers. According to the Minister of Manpower Regulation No. 5 of 2018 concerning Occupational Safety and Health in the Work Environment, the Threshold Limit Value (TLV) for noise exposure in the workplace for an 8-hour workday is 85 dB(A)[2]. The effects of noise exposure include physiological disturbances, hearing impairment, and psychological stress. Prolonged exposure to noise can lead to emotional instability, and if it persists, may cause stress in workers.

When a worker experiences stress, the body releases hormones such as epinephrine, norepinephrine, and cortisol in response to perceived threats by the brain. Chronic stress can cause vasoconstriction, resulting in the heart working harder and an increase in heart rate. These physiological changes can trigger elevated blood pressure and potentially lead to hypertension[3]. Increased blood pressure may also result from other factors, such as failure to use hearing protection while working. The use of ear protection is one way to reduce noise exposure; however, many workers choose not to use it due to discomfort during work[4].

High blood pressure, or hypertension, is a condition in which a person has a systolic blood pressure ≥140 mmHg and a diastolic blood pressure ≥90 mmHg. According to the World Health Organization (WHO), one billion people worldwide suffer from hypertension, with 66% living in low-income, developing countries[5]. Based on the 2018 Basic Health Research (Riskesdas), the prevalence of hypertension among Indonesians aged 18 and older is 34.1%, and this number is expected to increase. Hypertension ranks fourth as a cause of death across all age groups in Indonesia[6]. It is often referred to as the "silent killer" due to its asymptomatic nature and its association with cardiovascular diseases such as stroke, heart disease, kidney disorders, and ultimately, death[7].

Previous studies have shown a relationship between noise exposure and increased blood pressure. For instance, research conducted on wood factory workers in Jember reported a noise level of 98.1 dB(A), which was associated with elevated blood pressure. A similar study at PT X in Semarang revealed a noise intensity of 88.12 dB(A), also linked to increased diastolic blood pressure in workers[8]. However, limited research has been conducted specifically in the wood furniture industry, highlighting the need for further investigation. Therefore, this study aims to examine the relationship between occupational noise exposure and the incidence of hypertension among workers in the wood furniture industry.

MATERIALS AND RESEARCH METHODS

This study employed an observational analytic method with a cross-sectional design. The research was conducted at a wood furniture industry site in Tegal in March 2025. The sample size was determined using the Lemeshow formula and purposive sampling technique, resulting in a total of 100 respondents. Inclusion criteria included male workers aged ≤50 years with a minimum of one year of work experience. Exclusion criteria were individuals taking antihypertensive medication, those with a history of heart disease, hypertension, or diabetes, and contract workers.

Primary data collected included noise intensity, workers' blood pressure, and Body Mass Index (BMI), all of which were measured directly. Noise intensity measurements were taken during working hours (07:00–16:00) at hourly intervals using a Mastech MS6300 Sound Level Meter to obtain the 8-hour equivalent continuous noise level (Leq). Measurements were conducted at five locations: sawmill, reparation, rough mill, assembling, and finishing divisions. According to the Minister of Manpower Regulation No. 5 of 2018, the occupational noise exposure limit is 85 dB.

Blood pressure data were obtained using an Omron sphygmomanometer and measured by a physician. Blood pressure classification was based on the JNC-VII (2003) criteria, which categorize hypertension as systolic pressure ≥140 mmHg or diastolic pressure ≥90 mmHg. BMI was calculated using body weight and height measurements collected via standard weight scales and stadiometers.

Univariate data were presented in frequency distribution tables. Bivariate analysis was performed using the Chi-Square test to examine the association between independent and dependent variables, with a significance level of $\alpha < 0.05$. Ethical clearance for this study was obtained from the Health Research Ethics Committee of the Faculty of Public Health, Diponegoro University, with approval number: 183/EA/KEPK-FKM/2025.

RESEARCH RESULTS AND DISCUSSION

This study included only male respondents. The majority of respondents were under the age of 40. The following table presents the characteristics of the study respondents.

Table 1. Characteristics of Respondents

Variable	n	%
Blood Pressure		
- Normal	75	75
- Hypertension	25	25
Age		
- ≥ 40 years old	10	10
- < 40 years old	90	90
- Length of Employment		
- ≥ 7 years	26	26
- < 7 years	74	74
Obesity		
- Overweight/Obese (BMI ≥ 25 kg/m^2)	28	28
- Overweight/Obese (BMI < 25 kg/m^2)	72	72
- Smoking Habits		
- Yes	50	50
- No	50	50
- Sleep Duration		
- Inadequate (<8 hours/day)	82	82
- Adequate (≥8 hours/day)	18	18
- Earmuff Usage		
- Yes	71	71
- No	29	29

Table 1 shows that the majority of respondents had normal blood pressure. The average age of the respondents in this study was 31 years, with a mean working period of 6.5 years. Many respondents reported smoking habits and did not use hearing protection (earmuffs) during work. The youngest respondent was 19 years old, and the oldest was 50 years old. Furthermore, respondents had a minimum work duration of 1 year and a maximum of 22 years. Most respondents had a normal Body Mass Index (BMI) and reported inadequate sleep duration. Many of them slept fewer than 8 hours per night, and several often experienced nighttime awakenings. This condition led to poor sleep quality among the respondents.
Bivariate analysis was conducted to examine the relationships between noise intensity, earmuff usage, smoking habits, sleep duration, work duration, and obesity—as risk factors for hypertension. This analysis aimed to determine whether significant associations existed between these variables and the incidence of hypertension.

Table 2. Bivariate Analysis Results

Variable	*p-value*	Prevalence Ratio (PR)	95% CI
Noise Intensity	0,021*	3,619	1,300-10,075
Earmuff Usage	0,899	-	-
Smoking Habit	0,356	-	-
Sleep Duration	1,000	-	-
Working Duration	1,000	-	-
Obesity	0,005*	4,333	1,647-11,401

Note: p < 0.05 indicates statistically significant association.

Bivariate analysis in this study was conducted using the Chi-Square test to examine the association between independent variables (risk factors) and the occurrence of hypertension. The results demonstrated a statistically significant association between noise intensity (p = 0.021) and obesity (p = 0.005) with hypertension among workers in the wood furniture industry.
The Chi-Square test results revealed a significant relationship between noise intensity and the incidence of hypertension among production operators (p = 0.021). As shown in the table,

19 respondents (35.2%) who worked in areas where noise levels exceeded the Threshold Limit Value (≥85 dB(A)) were found to have hypertension. The high noise intensity originated from the operation of several machines such as CNC machines, sanders, and cutting machines. These machines operate simultaneously, thereby increasing the cumulative noise level in the workplace.

Exposure to high-intensity noise may reduce concentration, which increases the likelihood of operational errors. When prolonged over time, this can lead to hearing impairment and elevated stress levels, which in turn increase the risk of hypertension and other cardiovascular diseases. The calculated prevalence ratio (PR) was 3.619, indicating that respondents exposed to noise levels ≥85 dB(A) had nearly four times higher risk of developing hypertension compared to those exposed to lower levels (<85 dB(A))

Figure 1. Noise Intensity in the Sawmill Area

This study is consistent with research conducted on workers in China. Statistical analysis yielded a p-value of 0.017 with a prevalence ratio (PR) of 1.30 and a 95% Confidence Interval (CI) of 1.05–1.62. The study reported that participants exposed to high noise levels at the workplace (≥85 dB(A)) had a 28% higher risk of developing hypertension[9]. Another study also supports this finding, reporting a p-value of <0.0001 and a PR of 1.941 (95% CI: 1.471–2.561), indicating that respondents in the noise-exposed group had a 17.8% higher risk of hypertension compared to 9% in the control group[10]. A further significant study reported a p-value of 0.04 with a PR of 1.09 (95% CI: 1.01–1.18), explaining that the risk of hypertension among workers may occur even without impairment in hearing sensitivity[11].

High noise exposure has both short-term and long-term effects on exposed workers. High-frequency and high-intensity noise exposure significantly impacts stress hormone release through the activation of the sympathetic nervous system and the endocrine system. This activation triggers the release of stress hormones such as catecholamines, adrenaline, noradrenaline, and cortisol, which contribute to elevated blood pressure[12]. Additionally, an experimental study reported a temporary increase in salivary cortisol levels in healthy male university students following exposure to sound at a frequency of 3000 Hz and an intensity of 75 dB(A)[13].

Apart from noise intensity, obesity also demonstrated a significant association with the incidence of hypertension among production operator workers, with a p-value of 0.005. Bivariate analysis showed that 13 workers (46.4%) categorized as obese (BMI > 25 kg/m^2) experienced hypertension. Obesity is a known risk factor for various diseases and is influenced by multiple factors such as genetics, urbanization, sedentary lifestyle, and changes in dietary patterns. Obese individuals tend to have high intake of sugar, salt, and fat. The resulting prevalence ratio was 4.333, indicating that obese workers had a fourfold increased risk of developing hypertension.

Individuals categorized as obese have higher leptin levels, which can lead to increased thermogenesis due to the activation of the sympathetic nervous system, thereby potentially

triggering hypertension. Obese individuals require a greater blood volume. Furthermore, the higher fat mass in their bodies disrupts blood circulation processes, increasing blood supply demands, which in turn raises heart rate and blood pressure.

The findings of this study are consistent with previous research indicating that obesity is associated with hypertension. The referenced study reported that overweight individuals had a 1.61 times higher risk of hypertension, while those with obesity had a 2.35 times higher risk compared to individuals with normal weight[14]. Moreover, obesity has been identified as a significant predictor of elevated blood pressure. Another study found that as BMI categories increased, the prevalence of hypertension among respondents also rose[15]. However, these results contrast with findings from a study conducted among workers in Jordan, which found no association between obesity and hypertension[16]. Nevertheless, global data on hypertension prevalence and incidence indicate an increasing trend, particularly in developing countries. Obesity is also associated with other adverse health outcomes, including type 2 diabetes, chronic diseases, and cardiovascular disorders. Lifestyle changes, including modifications in dietary patterns, increased physical activity, and regular exercise, are necessary to prevent and manage obesity[17,18].

Statistical testing between the variable of hearing protection device use and the incidence of hypertension resulted in a p-value of 0.899 ($\alpha > 0.05$). These results indicate no significant association between the use of hearing protection devices and hypertension among workers in the wood furniture industry. This may be due to the fact that most respondents did not use hearing protection devices. This finding aligns with a study conducted among workers in Wuhan, which also found no relationship between the use of hearing protection and hypertension. The study suggested that this may be due to improper use of earmuffs or the use of cotton and earphones instead of appropriate hearing protection devices[19].

Statistical analysis of the variable of smoking habits and the incidence of hypertension yielded a p-value of 0.356 ($\alpha > 0.05$), indicating no significant association between smoking habits and hypertension among workers in the wood furniture industry. This non-significant result may be attributed to the fact that the majority of respondents were of productive age and engaged in sufficient physical activity. Adequate physical activity can help prevent hypertension among individuals of productive age by enhancing the body's resistance to disease, thus contributing to the low percentage of hypertension in this age group. [20].

A Chi-square statistical test examining the relationship between sleep duration and hypertension yielded a p-value of 1.000 ($\alpha > 0.05$), indicating no significant association. This may be due to the fact that most respondents with less than 8 hours of sleep did not experience hypertension. Individuals who sleep less than 7–8 hours per night may experience disruptions in their natural sleep patterns. Nocturnal dipping typically occurs at night, leading to the activation of the parasympathetic nervous system, which results in reduced blood pressure. Therefore, individuals who sleep 7–8 hours per night are at lower risk for hypertension[21].

Statistical analysis showed no significant association between work duration and the incidence of hypertension among workers. This may be due to the fact that most respondents had worked for less than 7 years and were under the age of 40, an age range considered young and productive. Younger respondents tend to have more active lifestyles and better metabolism, which may reduce the risk of hypertension[13]. A limitation of this study is its cross-sectional design, which may lead to temporal bias as data were collected at a single point in time.

CONCLUSIONS AND RECOMMENDATIONS

This study concludes that noise intensity ≥85 dB(A) is associated with a 3.6-fold increased risk of hypertension compared to workers exposed to noise intensity <85 dB(A). Furthermore, obesity among workers increases the risk of hypertension by 4.3 times. These findings highlight the importance of stricter occupational health and safety (OHS) policies in

the workplace, the provision of more adequate and compatible personal protective equipment (PPE), and health education and awareness programs for workers. Future research is recommended to explore the physiological mechanisms linking chronic noise exposure and metabolic disorders to hypertension and to evaluate the effectiveness of integrated occupational health strategies in reducing cardiovascular risk among industrial workers.

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