

The Influence of Gender, Body Mass Index, Work Fatigue and Noise Exposure on Blood Pressure among Manufacturing Industry Workers

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ABSTRACT

Background: Noise in the work environment can exceed a set threshold and have an impact on workers' health, including increased blood pressure. In addition to noise, other factors such as work fatigue, body mass index, and gender also contribute to the risk of hypertension. Preliminary studies show that exposure to high noise and manual work activities is at risk of causing fatigue, so it requires further analysis of the influence of these factors on the blood pressure of industrial workers.

Subjects and Method: The study design was a cross-sectional study. The study was conducted in Karanganyar Regency, Central Java in February-April 2025. Sampling in this study was conducted using the Fixed Exposure Sampling method, involving 200 worker samples from a herbal medicine factory and a fireworks factory in Karanganyar Regency, Central Java. The method used to collect data in this study was analytical observations with a cross-sectional approach. The analysis used in this study was path analysis. The dependent variable was blood pressure. The independent variables were noise exposure, fatigue, body mass index, and gender.

Results: Blood pressure increased with high fatigue ($b = 0.15$; 95% CI < 0.01 to 0.29 ; $p = 0.038$), noise exposure ($b = 0.15$; 95% CI $= 0.02$ to 0.28 ; $p = 0.020$). Blood pressure in female workers was lower than in men ($b = -0.14$; 95% CI $= -0.28$ to -0.01 ; $p = 0.034$). Blood pressure was indirectly affected by body mass index.

Conclusion: This study shows that noise exposure and work fatigue have a direct effect on increasing blood pressure; women have lower blood pressure than men, while body mass index has an indirect effect on increasing the blood pressure of workers.

Keywords: blood pressure, noise, work fatigue, body mass index, gender

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BACKGROUND

Noise in the work environment has been proven may exceed the specified threshold, as the results of a study by Erliana and Suhada., (2020) show that all measurement points in the engine room exceed the pre-determined noise threshold value of 85 dB for 8 working hours of exposure (Minister of Manpower, 2018). Noise is known to interfere with workers' health, including causing hypertension. Kelirey et al., (2023) stated that there is a significant correlation between noise and systolic and diastolic blood pressure.

World Health Organization (WHO) data in 2023 notes that the prevalence of hypertension globally reaches 33% or equivalent to one in three of the world's population (Ardiansyah and Widowati., 2024). In Indonesia, the 2022 employment report shows that the industrial sector accounts for the highest proportion of occupational disease incidence at 22.3%, with the majority of incident locations being in the workplace (Yuli et al., 2022).

In addition to noise, there are other factors that contribute to increased blood pressure, including body mass index, gender and work fatigue. A study by Wang et al., (2021) states that women are more susceptible to changes in the structure and function of the carotid arteries so that they are at a higher risk of developing hypertension. Diet and body mass index have also been shown to affect blood pressure (Wahyudi, 2024), as well as work fatigue, which shows a significant relationship with diastolic blood pressure (Ayuniyanti et al., 2024).

Preliminary study at X Herbal Medicine Company revealed that noise levels exceeded the threshold at several production points, including milling (90.2 dB), sifting (90.6 dB) and mixing (90.4 dB) sections. In addition, manual work processes such as packing activities that require static work for

8 hours per day also increase the risk of physical fatigue, especially in the lower back due to monotonous sitting positions .

Based on this description, this study is important to analyze the effect of exposure to noise, work fatigue, body mass index, and gender on blood pressure in workers in the manufacturing industry.

SUBJECTS AND METHOD

1. Study design

The study used an observational analytics design with a cross-sectional approach. The study was conducted in Karanganyar Regency, Central Java, Indonesia, from February to April 2025.

2. Population and Sample

The study population was production workers in a herbal medicine factory and a fireworks factory. A sample of 200 workers was selected using fixed exposure sampling.

3. Study Variables

The dependent variable in this study was the blood pressure of workers, while the independent variables were noise exposure, work fatigue, body mass index, and gender.

4. Operational Definition of Variables

Blood Pressure is the pressure that occurs inside the human arteries when blood is pumped by the heart to all the limbs of the body, and is represented by systolic and diastolic pressure.

Noise Exposure is all unwanted noises that come from work and production tools that, at a certain level, can interfere and cause losses such as hearing loss, physical, and material loss.

Work Fatigue is a feeling of fatigue felt by workers both physically and psychologically which results in a decrease in performance.

Body Mass Index is a measurement of body composition that uses weight and height, then calculates body mass index using the formula.

Gender is a biological category that distinguishes humans based on physical and reproductive characteristics, namely male and female qualities.

5. Study Instruments

The research instruments used for data collection are sound level meters, tension meters, weight scales and stadiometers.

6. Data Analysis

Univariate analysis of continuous data was conducted to obtain mean data, standard deviation, and minimum to maximum values. Bivariate analysis used regression tests with a significant level of $p < 0.05$, and multivariate analysis was conducted using Path Analysis.

7. Research Ethics

Research ethics issues, including informed consent, anonymity, and confidentiality, are

carefully addressed throughout the research process. The ethical clearance was obtained from the Research Ethics Committee at Dr. Moewardi Hospital, Surakarta, Indonesia, No. 2.632/XI/HREC-/2024, on November 13, 2024.

RESULTS

1. Sample Characteristic

Univariate analysis was conducted to determine the description or characteristics of the sample and study variables, namely gender, age, noise exposure, work fatigue, body mass index, and blood pressure. Based on the data obtained by the researcher in this study, it was discovered that the majority of the samples in this study were male.

Table 1. Sample characteristics (categorical data)

Variable	Category	Frequency	Percentage
Gender	Male	126	63%
	Female	74	37%

Table 2 continuous data of 200 study subjects indicates that age showed an average value of 40.05 years with a minimum value of 21 years and a maximum value of 55 years, noise exposure showed an average value of 60.08 dB with a minimum value of 41 dB and a maximum value of 88.8 dB, work fatigue showed an average value of 488.22 ms with a minimum value

of 244 ms and a maximum value of 676 ms, The body mass index showed an average value of 24.26 kg/m² with a minimum value of 17.01 kg/m² and a maximum value of 48.09 kg/m² and blood pressure showed an average value of 129.65 mmHg with a minimum value of 97 mmHg and a maximum value of 175 mmHg.

Table 2. Sample characteristics (continuous data)

Variable	Mean	SD	Minimum	Maximum
Age (years)	40.05	8.45	21	55
Noise exposure (dB)	60.08	11.19	41	88.8
Work fatigue (ms)	488.22	102.71	244	676
Body Mass Index (kg/m ²)	24.26	5.09	17.01	48.09
Blood pressure (mmHg)	129.65	16.50	97	175

2. Bivariate Analysis

Bivariate analysis was conducted to analyze the influence of variables of noise exposure, work fatigue, body mass index, and gender

on blood pressure. This analysis was conducted using a regression test.

Table 3 shows that noise exposure had a positive effect on blood pressure among

workers ($b = 0.27$; 95% CI= 0.07 to 0.47; $p = 0.008$). These results showed that noise exposure had an effect on blood pressure; this relationship was statistically significant. Work fatigue had a positive effect on blood pressure among workers ($b = 0.03$; 95% CI= 0.01 to 0.05; $p = 0.004$). These results showed that work fatigue had an effect on blood pressure; this relationship was statistically significant. Body mass index had a positive effect on blood pres-

sure among workers ($b = 1.06$; 95% CI= 0.64 to 1.49; $p < 0.001$). These results showed that body mass index had an effect on blood pressure; this relationship was statistically significant. Gender hurt blood pressure among workers ($b = -4.76$; CI 95%= -9.49 to -0.03; $p = 0.049$). These results showed that gender had an effect on blood pressure; this relationship was statistically significant.

Table 3 Bivariate analysis results of noise exposure, work fatigue, body mass index, and gender on blood pressure

Variable	Regression coefficient	95% CI		P
		Lower limit	Upper limit	
Noise exposure (dB)	0.27	0.07	0.47	0.008
Work Fatigue (ms)	0.03	0.01	0.05	0.004
Body Mass Index (kg/m ²)	1.06	0.64	1.49	<0.001
Gender (female)	-4.76	-9.49	-0.03	0.049

3. Multivariate Analysis

The analysis was conducted to explain the influence and direction of the relationship between noise exposure, work fatigue, body

mass index, and gender on blood pressure. This analysis was conducted using path analysis.

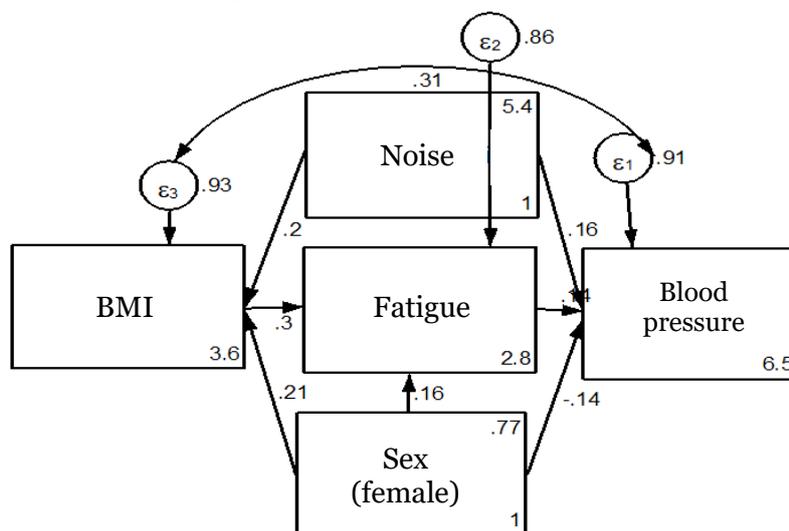


Figure 1. Structural model of path analysis with path coefficient estimates

Figure 1 explains the relationship between the variables blood pressure, work fatigue, body mass index, and gender. The images show that there was a positive relationship between noise exposure and work

fatigue on blood pressure. This means that the higher the noise exposure and the level of work fatigue, the higher the blood pressure among workers. Similarly, there was a positive relationship between blood

pressure and body mass index, which means that the higher the blood pressure,

the greater the body mass index of the worker.

Table 5. The results of the path analysis of the influence of noise exposure, work fatigue, body mass index, and gender on blood pressure

Dependent Variable	Independent Variables	Standardized Path Coefficient (b)	95% CI		p
			Lower limit	Upper limit	
Direct influence					
Blood pressure	←Fatigue (ms)	0.14	<0.01	0.27	0.041
	←Noise exposure (dB)	0.15	0.02	0.28	0.019
	←Gender (female)	-0.14	-0.28	-0.01	0.037
Indirect influence					
Mass	←Noise exposure (dB)	0.19	0.06	0.32	0.004
Body Index	←Gender (female)	0.21	0.08	0.34	0.001
Fatigue	←Body Mass Index (kg/m ²)	0.30	0.17	0.42	<0.001
	←Gender (female)	0.16	0.03	0.29	0.014
Chi-square(p)	= 0.078				
RMSEA	< 0.001				
CFI	= 1.00				
TLI	= 1.11				
SRMR	= 0.004				

Table 5 shows that there was a direct influence; fatigue had a positive relationship with blood pressure, and it was statistically significant (p=0.041). Each increase of 1 unit of fatigue was followed by an increase in blood pressure of 0.14 units (b=0.14; CI 95%= <0.01 to 0.27; p=0.041). Noise exposure had a positive relationship with blood pressure, and it was statistically significant (p=0.019). Each increase of 1 unit of noise intensity exposure is associated with an increase in blood pressure of 0.15 units (b=0.15; CI 95%= 0.02 to 0.28; p=0.019). Gender has a negative relationship with blood pressure, and it was statistically significant (p=0.037). Women had lower blood pressure than men by 0.14 units (b=-0.14; CI 95%= -0.28 to -0.01; p=0.037).

Table 5 shows that there was an indirect effect; noise exposure had a positive relationship with body mass index, and it was statistically significant (p=0.004). Each 1 unit increase in noise intensity exposure

was followed by an increase in body mass index of 0.19 units (b=0.19; CI 95%= 0.06 to 0.32; p=0.004). Gender had a positive relationship with body mass index, and it was statistically significant (p=0.001). Women have a higher body mass index than men by 0.21 units (b=0.21; CI 95%= 0.08 to 0.34; p=0.001). Body mass index had a positive relationship with fatigue, and it was statistically significant (p<0.001). Each increase in body mass index units was followed by an increase in fatigue of 0.30 units (b=0.30; CI 95%= 0.17 to 0.42; p<0.001). Gender had a positive relationship with fatigue, and it was statistically significant (p=0.014). Women had a higher fatigue than men by 0.16 units (b=0.16; CI 95%= 0.03 to 0.29; p=0.014). This path analysis model had a good model fit (Chi-square(p)= 0.078; RMSEA< 0.001; CFI= 1.00; TLI= 1.11; SRMR=0.004).

DISCUSSION

1. The influence of fatigue on blood pressure

This study found that there was a positive effect of work fatigue on workers' blood pressure. This study is in line with a study by Laily and Tualeka., (2023) who states that the average blood pressure of nurses (prehypertension) has a strong relationship with work fatigue, this relationship can occur because working for a long time with strenuous physical activity and lack of rest increase the body's energy needs so that there is an increase in sympathetic nerves which make blood vessels experience increased vasoconstriction and contractility of heart muscle, the cardiac output increases which has an impact on the increase in blood pressure.

However, this study was not in line with a study by Ryu et al. (2015) that found that in some individuals, fatigue does not cause an increase in blood pressure directly, because the body has a compensatory mechanism that keeps blood pressure stable even when fatigue occurs. In addition, some workers who are already accustomed to a high workload (habituation) may show physiological adaptation, so fatigue is not directly reflected in increased blood pressure.

2. The influence of noise exposure on blood pressure

In this study, it was found that there was a positive effect of noise exposure on the blood pressure of workers. This study is in line with a study by Luthfiyah and Widajati (2019), which states that there is a significant relationship between noise intensity and systolic blood pressure, with the strength of the relationship in the moderate and unidirectional categories, which means that the higher the noise intensity, the higher the systolic blood pressure of the workforce. In this study, noise exposure

affected blood pressure indirectly through body mass index, and it was statistically significant and had a positive relationship. A study by Persson et al., (2024) shows that long-term exposure to transport noise can contribute to an increased risk of obesity. The study is a combination of eleven cohorts in the Nordic region that found an association between traffic noise and an increased risk of obesity and central obesity. These findings reinforce the hypothesis that environmental factors such as noise have an impact on metabolic health through mechanisms such as sleep disturbances and chronic stress.

3. The influence of gender on blood pressure

The results of the study showed that there was a negative influence of gender on the blood pressure of workers; women had a lower blood pressure by 0.14 mmHg than men. Yanes et al., (2018) stated that before the age of 50, women had lower blood pressure than men, but this difference decreased or reversed after menopause. After women enter menopause, the prevalence in women will increase due to hormonal factors, namely a decrease in the hormone estrogen, an excessive response to androgens, increased oxidative stress and endothelins and changes in the renin-angiotensin-oxide system that function in maintaining the elasticity of blood vessels (Heryanti and Djokusujono., 2020).

In this study, gender indirectly affected blood pressure through fatigue, and it was statistically significant and had a positive relationship. The study is in line with a study by Jain et al., (2023) which shows that biological factors such as hormonal fluctuations during the menstrual cycle can affect stress and fatigue levels in women, women tend to experience a significant increase in stress at certain phases in the menstrual cycle, especially

when hormonal changes occur. This shows that the fatigue experienced by women is not only caused by workload or psychosocial stress, but is also influenced by the biological rhythms of the body which are cyclical.

Gender indirectly affected blood pressure through body mass index and it was statistically significant and had a positive relationship. These results are in line with the findings of Jeong et al. (2023) and Galgani et al., (2025) which show that women have a higher percentage of body fat than men at the same BMI value. These differences suggest that body composition influenced by gender needs to be taken into account in assessing health risks related to obesity, including blood pressure.

In addition, a study by Galgani et al., (2025) shows that women with a higher body mass index have a greater risk of hypertension, although the risk remains higher in men when obesity has occurred.

4. The Influence of body mass index on blood pressure

This study showed that body mass index affected blood pressure indirectly through fatigue, and it was proven to be statistically significant and had a positive relationship. This study is in line with a study by Ku et al., (2019) which states that obesity significantly increases the perceptioardin of the tendency to be tired by up to 94% compared to normal weight, every 1 unit increase in body mass index in the overweight/ obese group is followed by an increase in the Rating of Perceived Exertion (RPE) of ~0.11 points, with a non-linear and very strong effect on central obesity. In addition, a study by Abineno., (2022) shows that body mass index and systolic blood pressure have a significant relationship, while the relationship between body mass index and diastolic blood pressure has

negative outcomes among adults in Ponain Village.

AUTHOR CONTRIBUTION

Study data collection, data analysis, and article preparation were carried out by Nurvita Eka Rizky. Analysis and document review by Bhisma Murti, Sumardiyono, Setyo Sri Rahardjo, and Revi Gama Hatta Novika.

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CONFLICT OF INTEREST

There is no conflict of interest in this study.

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