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ORIGINAL

The Effect of Noise Intensity, Work Climate and Individual Characteristics on Blood Pressure of Workers PT Bungasari Flour Mills

El efecto de la intensidad del ruido, el clima laboral y las características individuales en la presión arterial de los trabajadores de PT Bungasari Flour Mills

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ABSTRACT

Introduction: K3 is important because workers are exposed to noise of 95,8-87,8 dBA and a working climate of ISBB 31,6°C which exceeds the threshold, so the influence of both and individual characteristics on workers› blood pressure at PT Bungasari Flour Mills Makassar was studied.
Method: cross-sectional observational analytical quantitative study; population of all PT Bungasari mill workers (100 people) with total sampling (n=100); instruments: characteristic form, SLM Svantek 971, noise dosimeter Svantek 104 (8 hours), Heat Stress Monitor QuesTemp 46 (WBGT), tensiometer, microtoise, digital scales; analysis in SPSS 23 (univariate, Chi-Square, and multiple logistic regression).
Results: the majority of workers were aged 26-35 years (37 %) with a high prevalence of smoking (86 %) and dominant obesity nutritional status (48 %), most of whom had worked for ≥4 years (68 %), and 73 % were exposed to noise and 70 % were exposed to hot working climates above the NAB; This condition was followed by an increase in mean blood pressure (systolic +4,90 mmHg; diastolic +4,08 mmHg) and the test results showed a significant relationship with a history of hypertension (p=0,010-0,014), nutritional status (p=0,001-0,002), smoking habits on systolic (p=0,044), work period (p<0,001), noise (p<0,001), and hot work climate (p=0,001-0,041), while age was only related to diastolic (p=0,010), alcohol (p>0,05) and work shifts (p>0,05) were not significant, and multivariate analysis showed that work period ≥4 years was the only significant predictor of systolic blood pressure (Adj-OR=0,022; p=0,002) and diastolic (Adj-OR=0,105; p=0,016).
Conclusions: noise intensity, work climate, and individual characteristics have a significant effect on workers' blood pressure, so it is necessary to strengthen health monitoring and control of the work environment to prevent hypertension.

Keywords: Noise; Work Climate; Individual Characteristics; Blood Pressure; Hypertension.

RESUMEN

Introducción: el K3 es importante debido a la exposición de los trabajadores a un ruido de 95,8-87,8 dBA y a un clima laboral de 31,6°C (ISBB), que supera el umbral. Por lo tanto, se estudió la influencia de ambos factores y de las características individuales en la presión arterial de los trabajadores de PT Bungasari Flour Mills Makassar.
Método: estudio cuantitativo analítico observacional transversal; población de todos los trabajadores del molino PT Bungasari (100 personas) con muestreo total (n=100); instrumentos: formulario característico, SLM Svantek 971, dosímetro de ruido Svantek 104 (8 horas), monitor de estrés térmico QuesTemp 46 (WBGT), tensiómetro, microtoise, básculas digitales; análisis en SPSS 23 (univariante, Chi-cuadrado y regresión

logística múltiple).
Resultados: la mayoría de los trabajadores tenían entre 26 y 35 años (37 %) con una alta prevalencia de tabaquismo (86 %) y un estado nutricional de obesidad dominante (48 %), la mayoría de los cuales había trabajado durante ≥4 años (68 %), y el 73 % estaba expuesto al ruido y el 70 % estaba expuesto a climas de trabajo cálidos por encima del NAB; Esta condición fue seguida por un aumento en la presión arterial media (sistólica +4,90 mmHg; diastólica +4,08 mmHg) y los resultados de la prueba mostraron una relación significativa con antecedentes de hipertensión (p = 0,010-0,014), estado nutricional (p = 0,001-0,002), hábitos de fumar sobre la sistólica (p = 0,044), período de trabajo (p < 0,001), ruido (p < 0,001) y clima de trabajo caluroso (p = 0,001-0,041), mientras que la edad solo se relacionó con la diastólica (p = 0,010), el alcohol (p > 0,05) y los turnos de trabajo (p > 0,05) no fueron significativos, y el análisis multivariado mostró que el período de trabajo ≥4 años fue el único predictor significativo de la presión arterial sistólica (OR ajustado = 0,022; p = 0,002) y la diastólica. (OR ajustado = 0,105; p = 0,016).
Conclusiones: la intensidad del ruido, el clima laboral y las características individuales tienen un efecto significativo en la presión arterial de los trabajadores, por lo que es necesario reforzar la vigilancia y el control de la salud en el entorno laboral para prevenir la hipertensión.

Palabras clave: Ruido; Clima Laboral; Características Individuales; Presión Arterial; Hipertensión.

INTRODUCTION

Occupational Health and Safety (K3) is crucial in production-based companies to ensure a sense of security, comfort, health, and safety so that optimal productivity is achieved;[1] Regulation of the Minister of Manpower No. 05 of 2018 confirms K3 as an inseparable part of the employment system that has a positive impact on social security and sustainable productivity. In the workplace, workers face various potential hazards—physical, chemical, biological, physiological/ergonomic, and psychological—originating from equipment, materials, processes, and environmental conditions, with the level of impact depending on the type, magnitude, and risk. Specifically, physical factors such as noise and work climate, short-term and prolonged exposure can cause health effects; research data shows that chronic noise exposure is correlated with an increased risk of hypertension and heart problems, for example, a study on automotive industry workers found that noise more than 80 dB significantly increased systolic and diastolic blood pressure after 4 hours of work.[2]

Meanwhile, several studies have shown a correlation between work climate and physiological performance disorders. Mousafi et al.[3] concluded that there was an increase in systolic blood pressure, diastolic blood pressure, heart rate, and body temperature in the group exposed to a hot work climate compared to the group not exposed. The results of the study conducted by Mukhlish et al. [4] showed that there was a significant relationship between noise levels and blood pressure P-value (0,011) and pulse rate in workers p value (0,004). In workers exposed to noise above normal, 60 % of respondents experienced an increase in high normal blood pressure, 28,9 % normal blood pressure values, 8,9 % with stage 1 and 2,2 % stage 3. Respondents who experienced tachycardia were 86 % and 13,3 % of respondents had a normal pulse 71,1 %. The study, similar to the study by, Umaidah et al.[5] showed a significant increase in systolic blood pressure, diastolic blood pressure, pulse rate between before and after work in acute noise exposure in wood factory workers.

The mechanisms of noise impact on the cardiovascular system include sympathetic nervous system activation, increased stress hormones (cortisol and adrenaline), and endothelial dysfunction;[6] in addition, extreme working climates—too hot/cold and high humidity—add thermoregulatory burdens that burden the cardiovascular system.[7] Globally, more than 5 % of the population (≈430 million people, including 34 million children) require rehabilitation for hearing loss, and it is projected that >700 million (1 in 10 people) will experience severe hearing loss by 2050; "disabling hearing loss" is defined as >35 dB in the better ear, with ~80 % of cases occurring in low-middle income countries and more than 25 % of those aged >60 years experiencing it. The OSH burden is also evident in the 2,78 million worker deaths per year according to the ILO, consisting of 2,4 million (86,3 %) occupational diseases and >380 thousand (13,7 %) accidents;[8] Low worker health awareness also triggers PAK, with hypertension being one of the most common. In Indonesia, the dominant use of machines/equipment in industry increases the risk of noise if not managed, so that some workers are exposed and potentially experience related health impacts.[9]

In industrial environments, exposure to high-intensity noise not only triggers hearing loss, but also reduces awareness and balance, disrupts mental health, communication, sleep, and task performance, affects physiological functions, and causes cardiovascular impacts such as increased heart rate, changes in blood pressure, and excessive sweating in exposed workers. Noise exposure—even in the range of 55–65 dBA—is associated with non-auditory disorders such as physiological, psychological, communication, comfort, and concentration disorders, triggers work fatigue, and long-term exposure increases the risk of cardiovascular disorders that can be monitored through blood pressure and heart rate.[10] Research by Midu et al.[11] shows that increased blood pressure/hypertension in workers is influenced by factors such as sleep duration, alcohol consumption, smoking, stress, noise, hot temperatures, and length of work, and is associated with increased work accidents—so workers with hypertension are at greater risk of injury and accidents in the workplace.

PT Bungasari Flour Mills Indonesia (PT) is located at Jl. Prof. Dr. Ir. Sutami No. 38, Tamalanrea, Makassar, occupying 24 865 m^2 of land with a building of 13 402,6 m^2 and operates equipment such as roller mills, purifiers, shifters, blowers, pneumatic conveyors, and compressors that have the potential to cause noise; the main source comes from friction/vibration of the Roller Mill and pressurized flow in the pneumatic system. The 2024 measurements showed noise of 95,8 dBA (1st floor Mill), 94,0 dBA (2nd floor Mill), and 87,8 dBA (Packing)—exceeding the NAB of 85 dBA for 8 working hours (Minister of Manpower Regulation No. 15/2018)—and the working climate in Packing with ISBB 31,6 °C exceeding the threshold of 31 °C for light loads (Minister of Manpower Regulation No. 05/2018). Referring to the Occupational Health and Safety (K3) regulations (Minister of Manpower Regulation No. 5/2018 and its guidelines), these findings confirm the potential dangers of physical factors (noise and work climate) to the health of workers, so the study was designed to assess the influence of noise intensity, work climate, and individual characteristics on workers' blood pressure at PT Bungasari Flour Mills.

METHOD

Type of study, period, and location

This research was a quantitative study with an analytical observational cross-sectional design conducted at PT Bungasari Flour Mills Makassar during August-September 2025.

Population and sample

The study population included all mill workers (N=100). A total sampling technique was applied, resulting in a sample of 100 workers. Inclusion criteria were: active production workers present during the study period and willing to participate. Exclusion criteria were: workers with incomplete measurements or medical conditions that prevented participation. Exit criteria included withdrawal during data collection or missing key variables.

Variables analyzed

The dependent variables were blood pressure components: systolic, diastolic, and pulse pressure (later dichotomized for logistic regression). Independent variables included age, family history of hypertension, nutritional status (BMI), smoking, alcohol consumption, work period, work shift, noise intensity (environmental and personal), and hot work climate (WBGT/ISBB). Noise and WBGT variables were emphasized due to their relevance in occupational health and their potential physiological impact on cardiovascular responses.

Instruments, techniques, and procedures

Environmental noise levels were measured using a Svantek 971 Sound Level Meter following SNI 7231:2009, while 8-hour personal noise exposure was measured with a Svantek 104 noise dosimeter. Work climate (WBGT/ISBB) was measured using a QuesTemp 46 Heat Stress Monitor in accordance with SNI 7061:2019. Blood pressure was measured using a calibrated digital tensiometer; height with a microtoise and weight with a digital scale to calculate BMI. All instruments had been externally calibrated before field use, and internal performance checks were conducted daily to ensure reliability. Measurement points were determined based on company layout and mapped according to Permenaker No. 5/2018.

Data collection process

Primary data were collected through worker characteristic forms and direct physiological and environmental measurements following standardized occupational hygiene procedures. Secondary data included company profiles and measurement-point maps. Measurements were conducted during workers' regular shifts to reflect actual exposure conditions.

Data analysis

Data processing in SPSS 23 included editing, coding, scoring, tabulating, and data entry. Univariate analysis produced frequency and percentage distributions. Bivariate analysis used the Chi-Square test with significance set at $p \leq 0,05$. Multivariate analysis used multiple logistic regression for dichotomous outcomes, with variable selection based on $p \leq 0,25$ as candidate predictors and $p \leq 0,05$ for final retention. A stepwise elimination approach was applied, using a >10 % change in coefficient or OR as a criterion. Odds ratios were reported as OR = exp(β).

Ethical aspects

This study obtained ethical approval from Faculty of Public Health Hasanuddin University with number

1526/UN4.14.1/TP.01.02/2025. All participants provided informed consent, and confidentiality was maintained throughout the research process.

RESULTS

PT Bungasari Flour Mills Indonesia—a wheat flour mill on Jl. Prof. Dr. Ir. Sutami No. 38, Tamalanrea, Makassar—operates 24 hours/day with 8-hour working hours/day for 6 days/week, with a capacity of 2 × 300 tons/day, on 24,865 m^2 of HGB land; a study conducted in August-September 2025 on 100 mill workers collected environmental observation data and individual characteristics (age, history of hypertension/medication, smoking, alcohol, shifts, length of service) using SLM Svantek 971, noise dosimeter Svantek 104, heat stress monitor QuesTemp 46, microtoise, digital scales, and tensiometers to measure work area noise, personal noise, work climate (ISBB), BMI, and blood pressure; Area noise measurements were carried out for 15 minutes, personal noise for 8 hours, and heat stress for 40 minutes at two points in each shift (morning, afternoon, night) in the packing area and mills machine area.

Table 1. Frequency Distribution of Respondent Characteristics

Variables	Category/Metric	Participants
Age	17-25 years old	19 (19 %)
	26-35 years old	37 (37 %)
	36-45 years old	27 (27 %)
	46-55 years old	17 (17 %)
History of hypertension	There is	8 (8 %)
	There isn't any	92 (92 %)
Nutritional status (BMI)	Fat	48 (48 %)
	Normal	46 (46 %)
	Thin	6 (6 %)
Smoking habit	Smoke	86 (86 %)
	Do not smoke	14 (14 %)
Alcohol consumption	Consuming	4 (4 %)
	Do not consume	96 (96 %)
Years of service	≥4 years	68 (68 %)
	<4 years	32 (32 %)
Work shift	Morning	38 (38 %)
	Afternoon	28 (28 %)
	Evening	34 (34 %)
Blood pressure		
Systolic (before work)	Mean / Median	122,85 / 121,5 mmHg
	Min / Max	85 / 197 mmHg
Systolic (after work)	Mean / Median	127,75 / 126,5 mmHg
	Min / Max	93 / 209 mmHg
Diastolic (before work)	Mean / Median	79,14 / 80 mmHg
	Min / Max	60 / 114 mmHg
Changes in blood pressure		
Systolic	Δ Mean	+4,90 mmHg
Diastolic	Δ Mean	+4,08 mmHg
Exposure to the work environment		
Noise	Above NAB	73 (73 %)
	Below NAB	27 (27 %)
Work climate	Above NAB	70 (70 %)
	Below NAB	30 (30 %)

The majority of respondents were aged 26-35 years (37 %), had no history of hypertension (92 %), but the prevalence of smoking was high (86 %) and overweight nutritional status was quite dominant (48 %); most had worked for ≥4 years (68 %) with a relatively balanced shift distribution. Exposure to physical factors was quite heavy—73 % above the TLV for noise and 70 % above the TLV for work climate—and was accompanied by an increase in mean blood pressure after work (systolic +4,90 mmHg; diastolic +4,08 mmHg), indicating the potential for acute work impacts on the cardiovascular system in this worker population.

Table 2. Relationship between Age and Systolic and Diastolic Blood Pressure

Respondent Age	Systolic Blood Pressure		p-value	Diastolic Blood Pressure		p-value
	Increase	Not increasing		Increase	Not increasing	
17-25 years	17 (89 %)	2 (11 %)	0,679	19 (100 %)	0 (0 %)	0,010
26-35 years	30 (81 %)	7 (19 %)		31 (83 %)	6 (17 %)	
36-45 years	21 (77 %)	6 (23 %)		17 (62 %)	10 (38 %)	
46-55 years	15 (88 %)	2 (12 %)		15 (88 %)	2 (12 %)	
Total	83 (83 %)	17 (17 %)		82 (82 %)	18 (18 %)	

The test results showed no significant association between age and increase in systolic blood pressure (p=0,679), although the largest proportion of increases was seen in the 26-35 year group (30 out of 37) followed by 36-45 year group (21/27); conversely, there was a significant association between age and increase in diastolic blood pressure (p=0,010), with the majority of all age groups showing an increase—but the 36-45 year group had a relatively higher proportion of "no increases" (10 out of 27) than the other groups, suggesting that age patterns may have a greater impact on the diastolic component than the systolic in this working population.

Table 3. Relationship between History of Hypertension and Systolic and Diastolic Blood Pressure

History of Hypertension	Systolic Blood Pressure		p-value	Diastolic Blood Pressure		p-value
	Increase	Not increasing		Increase	Not increasing	
There is a history	4 (50 %)	4 (50 %)	**0,010**	4 (50 %)	4 (50 %)	0,014
No history	79 (85 %)	13 (15 %)		78 (85 %)	14 (15 %)	
Total	83 (83 %)	17 (17 %)		82 (82 %)	18 (18 %)	

There was a significant association between a history of hypertension and increases in blood pressure, both systolic (p=0,010) and diastolic (p=0,014); interestingly, the proportion of increases was much higher in workers without a history of hypertension (systolic 79/92=85 %; diastolic 78/92=85 %) than in those with a history (both 4/8=50 %), indicating that post-workout blood pressure spikes were more common in the group without a history—possibly related to acute work exposure—while workers with a history may have been better controlled (e.g., due to medication/monitoring), although this reason needs to be confirmed by medication data.

Table 4. Relationship between Nutritional Status and Systolic and Diastolic Blood Pressure

Nutritional status	Systolic Blood Pressure		p-value	Diastolic Blood Pressure		p-value
	Increase	Not increasing		Increase	Not increasing	
Fat	46 (95 %)	2 (5 %)	0,001	46 (95 %)	2 (5 %)	0,002
Normal	31 (67 %)	15 (33 %)		31 (67 %)	15 (33 %)	
Thin	6 (100 %)	0 (0 %)		5 (83 %)	1 (17 %)	
Total	83 (83 %)	17 (17 %)		82 (82 %)	18 (18 %)	

There is a significant relationship between nutritional status and increased blood pressure, both systolic (p=0,001) and diastolic (p=0,002): the obese group showed the highest and consistent proportion of increase (systolic 46/48=95 %; diastolic 46/48=95 %), while the normal group was lower (systolic 31/46=67 %; diastolic 31/46=67 %), and the thin group appeared high but the number was very small (systolic 6/6=100 %; diastolic 5/6=83 %) so that its interpretation requires caution; overall, these findings indicate that overnutrition status is strongly correlated with increased blood pressure in workers.

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Table 5. Relationship between History of Hypertension and Systolic and Diastolic Blood Pressure						
Smoking Habit	**Systolic Blood Pressure**		**p-value**	**Diastolic Blood Pressure**		**p-value**
	Increase	**Not increasing**		**Increase**	**Not increasing**	
Smoke	74 (86 %)	12 (14 %)	0,044	72 (84 %)	14 (16 %)	0,267
Do not smoke	9 (64 %)	5 (36 %)		10 (71 %)	4 (29 %)	
Total	83 (83 %)	17 (17 %)		82 (82 %)	18 (18 %)	

There was a significant association between smoking and increased systolic blood pressure (p=0,044), with a higher proportion of increases in smokers (74/86=86 %) compared to non-smokers (9/14=64 %). Conversely, no significant association was found for diastolic blood pressure (p=0,267) although the proportion of increases in smokers (72/86=84 %) was higher than in non-smokers (10 of 14=72 %); these diastolic results also need to be interpreted cautiously due to the relatively small size of the non-smoker group (n=14).

Table 6. Relationship between Alcohol Consumption Habits and Systolic and Diastolic Blood Pressure						
Alcohol Consumption Habits	**Systolic Blood Pressure**		**p-value**	**Diastolic Blood Pressure**		**p-value**
	Increase	**Not increasing**		**Increase**	**Not increasing**	
Yes	4 (100 %)	0 (0 %)	0,356	3 (75 %)	1 (25 %)	0,710
No	79 (82 %)	17 (18 %)		79 (82 %)	17 (18 %)	
Total	83 (83 %)	17 (17 %)		82 (82 %)	18 (18 %)	

There was no significant association between alcohol consumption and increased blood pressure, either systolic (p=0,356) or diastolic (p=0,710). Although proportionally all drinkers (4/4) experienced an increase in systolic blood pressure and 75 % (3 of 4) experienced an increase in diastolic blood pressure, the very small size of the drinking group (n=4) likely made the statistical test underpowered to detect a difference.

Table 7. Relationship between Length of Service and Systolic and Diastolic Blood Pressure						
Years of service	**Systolic Blood Pressure**		**p-value**	**Diastolic Blood Pressure**		**p-value**
	Increase	**Not increasing**		**Increase**	**Not increasing**	
> 4 Years	67 (98 %)	1 (2 %)	0,001	63 (93 %)	5 (7 %)	0,001
< 4 Years	16 (50 %)	16 (50 %)		19 (59 %)	13 (41 %)	
Total	83 (83 %)	17 (17 %)		82 (82 %)	18 (18 %)	

Length of service was strongly and significantly associated with increases in blood pressure, both systolic (p<0,001) and diastolic (p<0,001). Workers with ≥4 years of service showed a significantly higher proportion of increases (systolic 67/68=98 %; diastolic 63/68=93 %) compared to workers with <4 years (systolic 16/32=50 %; diastolic 19/32=59 %). This pattern is consistent with the suspected cumulative effect of occupational exposures (e.g., noise/work climate) on cardiovascular responses, although potential confounders such as age, shift, and nutritional status still need to be controlled for in multivariate analyses.

Table 8. Relationship between Work Shifts and Systolic and Diastolic Blood Pressure						
Respondent Age	**Systolic Blood Pressure**		**p-value**	**Diastolic Blood Pressure**		**p-value**
	Increase	**Not increasing**		**Increase**	**Not increasing**	
Evening	29 (85 %)	5 (15 %)	0,408	27 (87 %)	4 (13 %)	0,408
Afternoon	21 (75 %)	7 (25 %)		24 (77 %)	7 (23 %)	
Morning	33 (87 %)	5 (13 %)		31 (82 %)	7 (18 %)	
Total	83 (83 %)	17 (17 %)		82 (82 %)	18 (18 %)	

There was no significant association between work shifts and increases in blood pressure, either systolic (p=0,408) or diastolic (p=0,408). Although the proportion of increases appeared slightly higher in the morning (systolic 33/38; diastolic 31/38) and night (systolic 29/34; diastolic 27/31) shifts compared to the afternoon shift, this difference was not statistically significant; a small note, the total recap of correct diastolic blood pressure was 82 increases and 18 did not increase (N=100), according to the summation per shift.

Table 9. Relationship between Noise Exposure and Systolic and Diastolic Blood Pressure

Noise Exposure	Systolic Blood Pressure		p-value	Diastolic Blood Pressure		p-value
	Increase	Not increasing		Increase	Not increasing	
Above NAB	68 (93 %)	5 (7 %)	0,001	66 (90 %)	7 (10 %)	0,001
Below NAB	15 (56 %)	12 (44 %)		16 (59 %)	11 (41 %)	
Total	83 (83 %)	17 (17 %)		82 (82 %)	18 (18 %)	

There was a highly significant association between noise exposure and increased blood pressure, both systolic (p<0,001) and diastolic (p<0,001). The proportion of increases was significantly higher in the group above the TLV (systolic 68/73=93 %; diastolic 66/73=90 %) than in the group below the TLV (systolic 15/27=56 %; diastolic 16/27=59 %), indicating that excessive noise exposure is strongly correlated with acute cardiovascular responses in workers. These findings are consistent with the suspected physiological effects of noise (sympathetic activation, hormonal stress), although the cross-sectional nature requires caution in causal inference.

Table 10. Relationship between Exposure to Hot Work Climate and Systolic and Diastolic Blood Pressure

Exposure to Hot Work Climates	Systolic Blood Pressure		p-value	Diastolic Blood Pressure		p-value
	Increase	Not increasing		Increase	Not increasing	
Above NAB	64 (91 %)	6 (9 %)	0,001	61 (87 %)	9 (13 %)	0,041
Below NAB	19 (63 %)	11 (37 %)		21 (70 %)	9 (30 %)	
Total	83 (83 %)	17 (17 %)		82 (82 %)	18 (18 %)	

Exposure to hot work climates was significantly associated with increased blood pressure—stronger in systolic blood pressure (p=0,001) and weaker but still significant in diastolic blood pressure (p=0,041). The proportion of increase was higher in the group above the TLV (systolic blood pressure 64/70=91 %; diastolic blood pressure 61/70=87 %) than in the group below the TLV (systolic blood pressure 19/30=63 %; diastolic blood pressure 21/30=70 %), indicating that excessive heat conditions may trigger an acute cardiovascular response in workers.

Table 11. SPSS Output of Logistic Regression Test of Variables Affecting Systolic Blood Pressure

Variables		Adj-OR (Exp.B)	95 % CI	P-value (Sig)
History of hypertension	There is	5,332	0,206-137,856	0,313
	No	-	-	-
Nutritional status	Fat	2,742	0,695-10,812	0,150
	Normal	-	-	-
	Thin	-	-	-
Smoking habit	Smoke	0,568	0,072-4,460	0,591
	Do not smoke	-	-	-
Years of service	≥4 years	0,022	0,002-0,235	0,002
	<4 years	-	-	-
Noise exposure	Above NAB	0,41	0,082-2,046	0,277
	Below NAB	-	-	-
Exposure to hot work climates	Above NAB	0,22	0,046-1,068	0,06
	Below NAB	-	-	-

After multivariate adjustment, the only significant predictor for increased systolic blood pressure was ≥4 years of service with Adj-OR=0,022 (95 % CI: 0,002-0,235; p=0,002) , meaning the odds of systolic increase in the ≥4 years of service group were significantly lower than those <4 years; other variables—history of hypertension (Adj-OR=5,332; p=0,313), overweight nutritional status (Adj-OR=2,742; p=0,150), smoking habit (Adj-OR=0,568; p=0,591), noise exposure above TLV (Adj-OR=0,410; p=0,277), and exposure to hot work climate above TLV (Adj-

OR=0,220; p=0,060)—were not significant, although work climate showed a trend (borderline). Wide confidence intervals for some covariates indicate imprecision of estimates and potential limitations in the power of the test/model (e.g., small subgroup sizes), as well as the possibility of confounding effects or "healthy worker effects" that make the direction of the association with tenure different from the bivariate analysis.

Table 12. SPSS Output of Logistic Regression Test on Variables Affecting Diastolic Blood Pressure

Variables		Adj-OR (Exp.B)	95 % CI	P value (Sig)
Age	17-25 years	-	-	-
	26-35 years old	1,92	0,176-20,921	0,592
	36-45 years old	11,198	0,664-188,854	0,094
	46-55 years	-	-	-
History of hypertension	There is	1,133	0,146-8,788	0,905
	No	-	-	-
Nutritional status	Fat	0,169	0,008-3,397	0,246
	Normal	1,524	0,106-21,868	0,757
	Thin	-	-	-
Years of service	≥4 years	0,105	0,017-0,66	0,016
	<4 years	-	-	-
Noise exposure	Above NAB	1,187	0,194-7,250	0,853
	Below NAB	-	-	-
Exposure to hot work climates	Above NAB	0,215	0,037-1,266	0,089
	Below NAB	-	-	-

In the diastolic model, tenure ≥4 years also appeared significant with Adj-OR=0,105 (95 % CI: 0,017–0,660; p=0,016), indicating a lower chance of diastolic increase in long tenure compared to <4 years; age 36-45 years showed a trend of increased risk (Adj-OR=11,198; p=0,094) and exposure to hot work climate tended to decrease the odds (Adj-OR=0,215; p=0,089), but both were not significant. History of hypertension, nutritional status, smoking habits, and noise exposure were not significant (p>0,05). The wide CIs for many covariates again emphasized the limitations of precision, so findings—especially borderline ones—should be interpreted cautiously and confirmed through further modeling (e.g., increasing sample size, checking for collinearity, and re-specifying the reference category).

DISCUSSION

This study aimed to understand the factors associated with increased systolic and diastolic blood pressure in workers. The results showed that individual factors and work environment factors contribute differently to blood pressure variations. Some findings support theory and international evidence, while others show inconsistencies that require further explanation. The results showed a trend toward increasing blood pressure with age. In the international literature, this mechanism is explained by the aging process's decline in blood vessel elasticity, which leads to increased arterial stiffness and increased systolic pressure, while diastolic pressure tends to increase in middle age before declining again in old age. Although some worker studies have found no significant association,[12] the reasons for this discrepancy likely stem from the relatively narrow age distribution of worker groups, variations in physical workload that can modify cardiovascular responses, and differences in recovery patterns across industry settings. This suggests that the effects of aging on blood pressure remain physiologically present, but their strength may be moderated by job characteristics.

A family or individual history of hypertension also showed a strong association with blood pressure in this study. International evidence suggests that genetic factors and modulation of the autonomic nervous system play a significant role, including decreased parasympathetic activity and increased cardiovascular reactivity to stress.[14] Inconsistent results from industry studies [13] may be influenced by the use of antihypertensive medications, lifestyle changes, or biases in workplace health monitoring. Nevertheless, physiologically, individuals with a history of hypertension remain on a higher risk trajectory. These research findings support the concept that genetic factors work in concert with environmental factors and workload.

Nutritional status, particularly elevated BMI, also contributes significantly to elevated blood pressure. Global evidence has confirmed that a BMI of 24,69–29,41 increases the risk of hypertension,[2] and even mild overweight increases the risk by approximately 3,7 times. The pathophysiological mechanisms underlying this

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association are complex, involving insulin resistance, low-grade inflammation, sympathetic nervous system activation, oxidative stress, and endothelial dysfunction. In the context of workers, variability in findings—for example, studies that found no significant association[13]—may be influenced by BMI homogeneity in the sample, adaptation of the body to the physical workload, or the presence of other protective factors such as daily physical activity. Therefore, although results are not always consistent, the pattern of association between increasing BMI and blood pressure is consistent with physiological and epidemiological evidence.

Smoking habits have shown variable associations in these studies. The mechanism of blood pressure elevation through sympathetic nerve activation, catecholamine release, and sudden vasoconstriction has been demonstrated in the literature, with an acute effect of approximately +10 mmHg systolic and +8 mmHg diastolic.[15] However, the inconsistency across studies [13] may be explained by variations in smoking intensity, duration of smoking, and lifestyle differences, including caffeine consumption and physical activity. In working populations, smoking is often accompanied by work stress, fatigue, or shift schedules, which can also modify blood pressure responses. This means that the relationship between smoking and blood pressure should be viewed as a dynamic behavioral-physiological interaction, rather than as a single effect.

Alcohol consumption, as demonstrated by several studies of workers,[4] has been shown to increase blood pressure through activation of the RAAS, increased cortisol, and changes in hemodynamics and blood acidity.[11] However, studies involving a low proportion of drinkers often find no significant association. This may be due to variability in drinking patterns, such as light drinking, episodic drinking, or infrequent drinking sessions. Differences in alcohol metabolism rates between individuals may also explain variations in blood pressure responses.

In addition to individual factors, job characteristics also play a significant role. Long work periods can lead to the accumulation of physical exposures such as noise and heat, as well as psychosocial stress. While some studies report no association between work period and blood pressure—for example, because the effects of noise are transient and resolve after rest[16]—other studies have found that repeated exposure over many years can lead to persistent physiological changes.[2] This suggests that the duration of exposure and the intensity of the workload are key factors in determining the effects of noise understand the variation in research results.

Shift work also contributes to blood pressure by affecting circadian rhythms. An international meta-analysis showed that night shifts can increase blood pressure,[17] with variations according to gender and work schedule.[5] However, if shift rotation is well-designed and includes sufficient recovery time, the impact can be minimized.[9] This suggests that it is not just the night shift itself that is influential, but also how the work organization regulates work-rest rhythms. Noise exposure increases sympathetic activity and causes vasoconstriction, thus tending to increase blood pressure. Evidence from various occupational sectors and countries supports this association at exposures >85 dBA.[12] However, fluctuating noise intensity, the use of personal protective equipment (PPE), and worker adaptations can mitigate the effect in some conditions. Heat exposure places additional stress on the cardiovascular system, especially at high WBGT such as 31,5.[3] Under extreme conditions, the body requires redistribution of blood flow and an increase in heart rate to maintain thermoregulation, ultimately increasing blood pressure. Work contexts with lower heat loads or better ventilation may produce non-significant findings.[9]

Overall, interpretation of the study results indicates that workers' blood pressure is influenced by a complex interaction between intrinsic factors (genetics, age, BMI, medical history) and extrinsic factors (heat, noise, shift work, and length of service). Inconsistencies between the results of this study and those of some international literature may be explained by differences in sample characteristics, exposure intensity, lifestyle variations, and physiological adaptation factors. Thus, the study findings not only confirm the physiological mechanisms identified in the global literature but also provide evidence that the local work context modifies the strength of the relationship between risk factors and blood pressure.

Implications

The implication of this research is that efforts to control hypertension in workers cannot focus on a single factor, because blood pressure is influenced by a complex interaction between individual characteristics, working conditions, and environmental factors. Overly focused interventions—for example, solely on lifestyle education—will be ineffective if workers are still exposed to high noise levels, excessive heat, or night shifts that disrupt circadian rhythms. Therefore, a comprehensive approach is needed, including controlling physical exposures such as noise and heat, optimizing ventilation, improving ergonomics, and rearranging shifts that take physiological recovery time into account. Furthermore, health promotion programs such as weight management, smoking cessation, and reducing alcohol consumption need to be integrated with regular blood pressure monitoring and consistent medical follow-up. Implementing structured cardiovascular screening—especially for workers with a history of hypertension or at high risk—can improve early detection and accelerate the implementation of appropriate interventions.

The results of this study also provide an empirical basis for strengthening Occupational Health and Safety

(OHS) policies that prioritize cardiovascular health. Many current OHS regulations focus primarily on physical safety aspects, while cardiometabolic risks—which have a greater long-term impact on worker productivity and health—often receive less attention. The findings regarding the influence of age, BMI, shift work, heat exposure, and noise emphasize that hypertension risk must be managed as an integral part of an OHS management system. This opens up opportunities for the development of more specific work standards, such as heat exposure limits that consider cardiovascular load, shift rotation guidelines that maintain biological rhythms, and mandatory periodic health checks focused on cardiometabolic parameters. With this integration, OHS policies not only serve to prevent workplace accidents but also strengthen the long-term sustainability of workers' health.

Limitations

This study has several limitations. The cross-sectional design cannot confirm causality, so interpretation remains associative. Measurement of some behavioral variables, such as smoking and alcohol consumption, relied on self-reports, which can potentially introduce bias. Variations in exposure intensity and differences in job characteristics may also limit generalizability. Furthermore, other factors, such as job stress, sleep quality, and physical activity, which can influence blood pressure, were not analyzed in depth.

CONCLUSIONS

Based on the research results, noise intensity, work climate, and individual characteristics were proven to influence the blood pressure of workers at PT Bungasari Flour Mills, where age, history of hypertension, nutritional status, smoking habits, length of service, noise, and work climate were proven to be significant on systolic and/or diastolic blood pressure, while alcohol consumption and work shifts had no effect; therefore, it is recommended that the company strengthen technology-based health monitoring systems (wearable, K3 dashboard, big data), control of noise exposure and work climate (engineering-administrative control and PPE), risk-based job rotation, and personal prevention programs such as nutrition management, smoking cessation, and digital screening before work to reduce the risk of long-term hypertension.

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CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

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