

Hypertension and Its Association with Noise Exposure among Blacksmith Workers in an Indonesian Village

Christopher F. Jaya², Marsen Isbayuputra¹, Jenny Bashiruddin³, Dewi Sumaryani Soemarmo¹, Rino Alvani Gani⁴

¹Department of Community Medicine, Faculty of Medicine, Universitas Indonesia, Jakarta, Indonesia

²Master of Occupational Medicine Study Program, Faculty of Medicine, Universitas Indonesia, Jakarta

³Department of Ear Nose and Throat, Faculty of Medicine, Universitas Indonesia, Jakarta, Indonesia

⁴Department of Internal Medicine, Faculty of Medicine, Universitas Indonesia, Jakarta, Indonesia

Corresponding author: Christopher F. Jaya

E-mail: chris.filbert@gmail.com

Abstract

Background: Blacksmith workers are at high risk of hypertension due to occupational exposures such as noise, heat, and heavy physical activity. Although noise exposure has been linked to cardiovascular stress through sympathetic activation, evidence regarding its direct association with hypertension in informal workers remains limited.

Objective: To determine the prevalence of hypertension and its associated factors among blacksmith workers in an Indonesian village and to identify whether occupational noise exposure contributes to increased blood pressure.

Methods: This was an analytical observational study with a cross-sectional design involving 107 blacksmith workers. Data were collected through interviews, blood pressure measurements, noise level assessment using a sound level meter, and body mass index (BMI) calculation. Bivariate analysis used Chi-square and Mann-Whitney tests, while multivariate analysis used logistic regression.

Results: The prevalence of hypertension was 34.5%. Bivariate analysis showed significant associations between noise intensity ($p=0.008$), age ($p=0.001$), working duration ($p=0.042$), smoking degree ($p=0.002$), and BMI ($p<0.001$) with hypertension, whereas noise type was not significant ($p>0.05$). In multivariate analysis, only BMI remained significant ($aOR=2$; 95% CI: 1.3–3.3).

Conclusion: The prevalence of hypertension was 34.5%. BMI is an independent risk factor for hypertension among blacksmith workers. Noise exposure was not significantly associated with increased blood pressure, likely due to confounding effects and non-differential noise types. Interventions should focus on weight management and regular blood pressure monitoring in this worker population.

Keywords: hypertension, occupational noise, blacksmith, body mass index, occupational medicine

Abstrak

Latar Belakang: Pekerja pandai besi memiliki risiko tinggi terhadap hipertensi akibat pajanan faktor okupasi seperti kebisingan, suhu tinggi, dan aktivitas fisik berat. Meskipun kebisingan diketahui dapat memengaruhi sistem kardiovaskular melalui mekanisme stres dan aktivasi saraf simpatis, bukti hubungan langsung antara pajanan kebisingan dan hipertensi pada pekerja informal masih terbatas.

Tujuan: Mengetahui prevalensi hipertensi dan faktor-faktor yang berhubungan dengan tekanan darah pada pekerja pandai besi di sebuah desa di Indonesia, serta menentukan apakah kebisingan merupakan faktor risiko yang berpengaruh terhadap hipertensi.

Metode: Penelitian ini merupakan studi analitik observasional dengan desain potong lintang pada 107 pekerja pandai besi di sebuah desa di Indonesia. Data dikumpulkan melalui wawancara, pengukuran tekanan darah, pengukuran kebisingan menggunakan sound level meter, serta pemeriksaan indeks massa tubuh. Analisis bivariat dilakukan dengan uji Chi-square dan Mann-Whitney, sedangkan analisis multivariat menggunakan regresi logistik.

Hasil: Prevalensi hipertensi pada pekerja pandai besi sebesar 34,5%. Hasil analisis bivariat menunjukkan adanya hubungan bermakna antara kebisingan ($p=0,008$), usia ($p=0,001$), lama kerja ($p=0,042$), derajat merokok ($p=0,002$), dan IMT ($p<0,001$) dengan tekanan darah, sedangkan jenis kebisingan tidak signifikan ($p>0,05$). Pada analisis multivariat, hanya IMT yang tetap signifikan ($aOR=2$; 95% CI: 1,3–3,3).

Kesimpulan: Prevalensi hipertensi pada pekerja pandai besi sebesar 34,5%. IMT merupakan faktor risiko independen terhadap hipertensi pada pekerja pandai besi. Pajanan kebisingan tidak terbukti meningkatkan risiko hipertensi, kemungkinan dipengaruhi oleh efek confounding dan variasi jenis kebisingan yang tidak kontras. Upaya pengendalian berat badan dan pemantauan tekanan darah berkala perlu ditingkatkan pada kelompok pekerja ini.

Kata kunci: hipertensi, kebisingan kerja, pandai besi, indeks massa tubuh, kedokteran kerja

Introduction

Hypertension is a disease that contributes to the most premature death in the world. There are estimated 1.28 million adults with hypertension age ranged around 30 – 79 in the world, and most of them are in the developed country. Estimated 46% adults with hypertension did not realise that they have hypertension. Only less than half of adults with hypertension (42%) were diagnosed and got medication. Estimated 1 of 5 adults with hypertension are controlled with medication. According to Indonesian health survey 2023 (SKI 2023), Indonesia has an average hypertension case diagnosed by doctor by 8%, and the average based on measurement around 29.2%. In the West Java, hypertension has a hypertension prevalence of 32.6%.^{1,2}

In blacksmith industry it usually involves forging and grinding. Blacksmith is an industry with one of the highest noise hazards. Hearing loss usually associated with workers exposed to high intensity noise hazard. But noise hazard can also affect non hearing functions such as sleep disorder, change of cortisol serum, cardiovascular disease, and work-related accident.^{3,4}

Other study tried to find the association between noise hazard and non-hearing effect, usually using the same cut off as time weighed average (8 hours work for 85 dB). There is other study that shows noise hazard under 85 dB can cause non hearing effect. Other study (Berglung et al) shows that there are association between stress and noise hazard at 55 dB, and cardiovascular disease at 65 dB(4)

Study that was conducted to sack manufacturing workers (Ismaila et al), shows that blood pressure increases when working. But that effect not only because of the noise hazard, but because of the shift work. This can happen if there are shift workers. There are significant blood pressure differences between those that exposed to noise hazard, and those who did not exposed. The result of this study concludes that systole blood pressure increases because of the noise hazard while diastole blood pressure did not show any significant difference between night and day shift, and when working. Their blood pressure shows increase start from 86 dB.^{5,6}

There are also study the association between noise hazard and hypertension in a cable manufacturing industry in West Java (Damar et al), shows that there are significant association between noise intensity and

age affect blood pressure while there are no significant association between noise type, work duration, and smoking that affect blood pressure. The prevalence of prehypertension is 31%, grade I hypertension is 20%, and grade II hypertension is 9%. The prevalence of hypertension on that study mostly are workers that exposed to high intensity noise hazard (>85 dB).

This study was conducted in a village in Ciwidey, West Java. Its citizen has a culture to work mostly as a blacksmith from their ancestors. They produce tools such as machete, knife and scythe. This village is one of the biggest centres for manufacturing machete in West Bandung. The workers here use traditional method and almost everything done manually. Most of them are not using proper personal protective equipment (PPE). All of the workers here work in small workshops. In this manufacture there are many hazards one of them are noise hazards produced from forging and grinding that some has the intensity of 85 dB or more. According to the local medical centre, most blacksmith workers had hypertension as the most top 1 disease. Therefore, it needs an analyse if there are occupational factor that have association with high blood pressure.

Methods

The design of this study is cross sectional, conducted in M Village, Ciwidey, West Java. This study conducted in August to December 2025. The subjects are workers that already work as a blacksmith for at least one year, and in a workshop with forging and grinding. If the worker had a history of medication of hypertension, dyslipidaemia, kidney failure will be excluded. Worker with hearing PPE usage also will be excluded. We got 107 samples using cluster sampling based on neighbourhood unit.

The independent variable for this study is the noise intensity, and the dependant variable is the blood pressure categorised as hypertension and non-hypertension. For other variables we recorded the type of noise, age with cut off age 40 years old, physical activity, smoking habit with cut off 10 years, smoking degree using brinkman index, sleep duration habit, and BMI categorized as obese and not obese.

The data for this study obtained from interview (age, physical activity, smoking habit and degree, sleep habit), physical examination (blood pressure and BMI), and measuring environment (Noise intensity, type, and temperature). We did interview with each worker

about their physical activity habit in a week, smoking duration and degree based on index brinkman in one year, and sleep habit duration in a week. For physical examination we use calibrated digital tensimeter, digital weight scale and digital stature meter. For measuring environment we're using calibrated sound level meter, and wet bulb globe temperature (WBGT) for measuring the temperature.

The measurement of noise and temperature conducted start from 9 AM to 12 PM in the middle of their work shift. Sound level meter placed near each worker's ear for 10 minutes and then count the average as referenced by Indonesian ministry of living environment. For the temperature we place the WBGT inside the workshop, measure for 30 minutes for 3 times and then count the average of WBGT. We informed the workers at 12 PM we will have an interview session and physical examination and ask them not to consume caffeine (smoke or coffee) 30 minutes before.^{6,8}

During their break time at 12 PM we asked them to sit and relax for 10 minutes while we ask questionnaires about their health history, daily and work habits. After that we check the blood pressure using digital tensimeter twice each worker with range 1 minute, and then we count the average each systole and diastole. Then we measure the BMI using stature meter and digital weigh scale.^{6,9}

The data recorded analysed using SPSS 27. Then we made the descriptive table for every neighbourhood unit data that we obtained. Bivariate analysis will be using chi square if categoric, using t test if normal distribution, and Mann Whitney if numeric data not normal distribution. For multivariate analysis used a logistic regression. This study received ethical approval from the FKUI-RSCM Ethics Committee (KET-1074/UN2.F1/ETIK/PPM.00.02/2025).

Results

This study involves blacksmith workers from neighbourhood unit 1, 3, 8, and 11. We got a total of 145 workers. Then 38 workers were excluded because they met the exclusion criteria such as hypertension medication, wearing hearing PPE (ear muff), or there is no forging or grinding activity. the total of the sample in this study are 107 workers that met the criteria.

The unit that had the most workshops are unit 8 (10.28%), meanwhile unit 3 has the most workers

Table 1. Respondent characteristics

	Total (n) Mean $\pm$ SD / Median (Min-Max)	Percentage (%)
Noise intensity:	76.6 (56.8 – 93.5)	
≥ 80 dB	35	32.7
< 80 dB	72	67.3
Work duration:	15 (1-45)	
≥ 10 years	80	74.8
< 10 years	27	25.2
Age:	41.1 $\pm$ 10.7	
≥ 40 years old	61	57
< 40 years old	46	43
Work temperature	28.5 (24.4-35)	
Noise type:		
Intermittent	56	52.3
Impact	49	45.8
Continuous	2	1.9
Physical activity:		
None	69	64.5
Less	33	30.8
Adequate	5	4.7
Smoke habit		
≥ 10 years	77	72
< 10 years	10	9.3
Not smoking	20	18.7
Smoking degree		
Severe	6	5.6
Moderate	34	31.8
Mild	47	43.9
Not smoking	20	18.7
Sleep habit		
< 7 hours	38	35.5
≥ 7 hours	69	64.5
BMI		
Obese	27	25.2
Not obese	80	74.8
Blood pressure		
Hypertension	37	34.6
Not hypertension	70	65.4

(38.31%). Unit that had the most hypertension prevalence is unit 3 (15.88%), and unit 11 had the most noise intensity 80 dB or above. Unit 11 had the highest noise because there are many grinding activities there.

The noise intensity in this study has a median of 76,6 dB (56.8 – 93.5). This shows that the median noise intensity is still below TWA for working 8 hours (≤ 85 dB). There are still some of the workers exposed 85 dB or above. The majority of the workers are exposed below 80 dB (67.3%)

For the duration of work, they have a median of 15 working years as blacksmith with a range from 1 years to 45 years work. The majority of the respondent has the experience of working as blacksmith for 10 years or more (74.8%). This shows that they have a high commitment working as blacksmith and has been a culture in that village for years.

The age of the workers has the average of 41 years old. This shows that most of the workers are still in productive age. Majority of the workers are 40 years old or more (57%).

For the work temperature shows that it has a range from 24.4 C to 35 C with 28.5 C as the median. This shows that the work temperatures are high because of the tropical weather and the forging activity.

Intermittent noise type is the majority in this study (52.3%) because most high intensity noise are caused by grinding. Then followed by impact type noise (45.8%). The least is continuous (1.9%) because only few of them using machines for work.

Majority of the workers don't do regular exercise outside work (64.5%). Followed by workers that do exercise but less than 150 minutes per week (30.8%). The last are workers that have sufficient exercise (4.7%).

The workers mostly have smoking habits for 10 years or more (72%). 18.7% workers didn't smoke. The least are workers that smoke less than 10 years (9.3%). As for the smoker degree most of workers are mild smokers (43.9%), followed by moderate smoker (31.8%), and least severe smokers (5.6%).

Workers mostly have a habit of sleep 7 hours or more every day (54.4%). While 35.5% workers have a habit of sleep less than 7 hours every day. For BMI most workers are not obese (74.8%), while 25.2% workers are obese. For the blood pressure mostly are non-hypertension (65.4%), followed by hypertension (34.6%).

Bivariate analysis conducted to find the significant association between variables and blood pressure. The

results are the blood pressure is statistically significant with variables including noise intensity, work duration, age, smoking degree, and BMI. Those variables will proceed to multivariate logistic regression analysis.

For the results of multivariate analysis variables include noise intensity, work duration, age, and smoking degree are statistically doesn't have significant association with blood pressure while in the bivariate these variables were significant. BMI is the only variable that is consistent have significant association with blood pressure both in bivariate and multivariate. Physical activity, smoking habit, sleep habit, noise type, and work temperature are not statistically having significant association with blood pressure.

Discussion

This study finds that the prevalence of hypertension among blacksmith workers in M Village has a rate of 34.6%. Even higher rate than the rate previously in SKI 2023 (29.2%). This also explains why the data from the local health centre in that village that hypertension is the highest disease among blacksmiths. This higher rate is either caused by blacksmith working hazard, or their lifestyle. Not all of the variables in this study shows statistically significant association toward blood pressure.

From the multivariate analysis of noise intensity, we do not get a significant result association with blood pressure. In theory, high intensity noise usually starts from 80 dB and above can cause hypertension. The noise will give psychosocial stress to workers. Their body will respond with activation of the sympathetic nerve. Then the body will increase the secretion of adrenaline and cortisol which leads to high blood pressure. In the future, obtaining stress work data might be important to support this. Other study (Souza et al) has results that starting 70 dB and above have significant association towards blood pressure, but their study records the noise hazard around 75% of their work shift which is longer and more representative than the method we use. If we use the TWA standard the median noise intensity in this study still not reached 85 dB for 8 hours work so it's still safe. Other cause for this non-significant result may be caused by the confounding from the multivariate analysis. Hypertension is known for multifactorial causes. After being analysed with other variable at the same time the noise variable is not significant enough

Table 2. Multivariate analysis results

	Blood pressure		P Value	OR (CI 95%)	P Value Multivariate	aOR (CI 95%)
	Hypertension	Non-hypertension				
Noise intensity						
≥80 dB	6 (5.6%)	29 (27.1%)	0.008 ^{cs}	0.2 (0.1 - 0.7)	0.05	0.3 (0.1 - 1)
<80 dB	31 (28.98)	41 (38.32%)				
Work duration:						
≥10 years	32 (29.9%)	48 (45%)	0.042 ^{cs}	2.9 (1 - 8.5)	0.185	2.4 (0.6 - 9)
<10 years	5 (4.6%)	22 (20.5%)				
Age:						
≥40 years	29 (27.1%)	32 (30%)	0.001 ^{cs}	4.3 (1.7 - 10.7)	0.116	2.3 (0.8 - 6.8)
<40 years	8 (7.4%)	38 (35.5%)				
Smoking Degree:						
Severe	4 (3.7%)	2 (1.2%)	0.002 ^{cs}	-	0.305	1.3 (0.7 - 2.3)
Moderate	16 (14.9%)	18 (16.8%)				
Mild	7 (6.5%)	40 (37.3%)				
Non smoker	10 (9.3%)	10 (9.3%)				
BMI						
Obese	18 (16.8%)	9 (8.5%)	<0.001 ^{cs}	6.4 (2.4 - 16.62)	0.002	2 (1.3 - 3.3)
Non-Obese	19 (17.7)	61 (57%)				
Physical activity						
None	25 (23.3%)	44 (41.1%)	0.75 ^{cs}	-	-	-
Less	11 (10.2%)	22 (20.5%)				
Sufficient	1 (0.9%)	4 (4%)				
Smoking habit						
≥10 Years	24 (22.4%)	53 (49.7%)	0.274 ^{cs}	-	-	-
<10 Years	3 (2.8%)	7 (6.5%)				
Not smoking	10 (9.3%)	10 (9.3%)				
Sleep habit						
Less	12 (11.2%)	26 (24.4%)	0.628 ^{cs}	1.2 (0.5 - 2.8)	-	-
Sufficient	25 (23.3%)	44 (41.1%)				
Noise type						
Intermittent	19 (17.7%)	37 (35.5%)	0.895 ^{cs}	-	-	-
Impact	17 (15.8)	32 (29.2%)				
Continuous	1 (0.9%)	1(0.9%)				
Work Temperature	28.5 C (25.6 – 32.8)	28.75 C (24.4 – 35)	0.289 ^{mw}	-	-	-

Cs = Chi Square; mw = Mann Whitney

compared with another variable. The numeric data of the noise intensity was also not distributed normally. Workers that exposed to noise intensity below 80 dB was far more (67.3%) than the other. The workers that have hypertension majority are exposed to noise below 80 dB. The design of each workshop does not have standard for the total of grinder and forger so every workshop may have a significant difference in noise hazard. Workers still have to be cautious and control the noise hazard such as PPE so that it may not cause hypertension in the future.¹²⁻¹⁰

For the noise type variable does not have significant association with blood pressure. Noise type can affect the exposure of the noise hazard. Impact type will give less average noise hazard compared to intermittent or continuous. Impact will only give noise when the hammer hit the iron. Since this is a traditional work, the impact noise is not as high as using machinery. Study from Damar et al, have the same result that noise type did not have significant association with blood pressure. From WHO also states that hypertension can be caused by high intensity noise hazard. They did not mention about the noise type as long as the noise intensity average meets the limit.^{4,6,13}

Age has a significant association with blood pressure in bivariate, and then did not have significant association in multivariate. Arteries muscle can become stiff and harder to vasodilate along with aging. This can be caused by confounding effect because there is another factor that is more significant. Age is not an independent variable because the more worker ages, also the more work duration, and possibly affect their BMI. BMI increase during most adult life reaching highest in the sixth decade of life. Changes in body fat are dependent on the energy balance. An increase in energy intake, and mobility decreasing with age are the primary causes of the bodyfat accumulation.^{14,15}

For physical activity, there are statistically no significant association with blood pressure. People that are not physically active will lead their arteries can become stiff and hard to vasodilate. This result can be caused because blacksmiths are workers with already high physical activity. According to Centres for Disease Control (CDC) and compendium of Physical Activities 2011 recommend that we should be moderately physically active (3-5.9 METs) while blacksmiths are categorised as workers with 5.3 – 8.3 METs. This shows that without physical activities outside working such as aerobic exercise, these workers

already considered physically active. Although it's still working as blacksmiths cannot replace aerobic exercise completely because of the ergonomics and only certain body parts moved when working. Other that may cause not significant is because we obtained data using interview about their exercise habits in the last 1 months. This can lead to self-reporting, or recall bias.^{12,16,17}

Smoking degree at bivariate analysis shows that there are statistically significant association. Both smoking degree and duration statistically did not have significant association in multivariate analysis. Smoking can increase blood pressure because of the nicotine. It has an adrenergic effect to activate sympathetic nerve that leads to increase blood pressure or increase the risk of atherosclerosis. It's known that smoking can cause acute increase blood pressure and temporary. In this study the respondent did not consume coffee or smoking 30 minutes before examine the blood pressure to make sure the respondent is not affected by adrenergic substance.¹⁸⁻²⁰

The majority of respondent sleeps at least 7 hours or more every day. This leads to result that there are statistically no significant association between blood pressure and sleeping habit. It's recommended to sleep every day at least 7 hours or more. Not sufficient duration of sleep can cause body get fatigue and activate sympathetic nerves that will increase blood pressure.^{21,22}

BMI consistently is the most statistically has significant association with blood pressure both in multivariate and bivariate. A body with excessive fat will increase the peripheral vascular resistance and increase heart output. The effect of obesity on blood pressure may depend on how long a person has been overweight, worsening as excess adiposity is maintained during several years. This means that obesity take shorter time to cause increased blood pressure than noise hazard that may take around 10 years. Which is why in this study IMT is the most significant while noise hazard is not. WHO states that obese is one of the main factors of hypertension and it's recommended to maintain ideal bodyweight. Because BMI is the most significant factor, there's a possibility that hypertension in blacksmith workers is caused by their lifestyle.^{2,23-25}

In this study there are statistically has significant association between work duration and blood pressure in bivariate, and no significant association in multivariate analysis. Work duration also not independent. Work duration, age, and BMI increase overtime and can cause confounding variable effect. This result also

supported by Damar et al that blood pressure does not have significant association with work duration. While Souza et al, finds that there are significant association between work duration and blood pressure, the noise hazard intensity in that study is higher more than 85 dB for 10 years working. In this study majority of the respondent works for 10 years or more and the data is not normally distributed.⁶

Work temperature statistically does not have significant association with blood pressure. The median in this study is 28.5 °C. Study conducted by Lestari et al about workers in steel factory works around 30.2 °C and have significant association with blood pressure. The temperature in this study is still lower than that. This can be caused because the source of heat is relatively small when compared to larger industrial scale. High temperature can cause blood vessel in the skin vasodilatation, but visceral arterial will vasoconstrict to compensate that will lead to increase blood pressure.²⁶

Conclusion

Hypertension prevalence for blacksmith workers in this study is 34.6%. It's higher than previously recorded in SKI 2023. The noise intensity in this study has a median of 77.6 dB with minimum 56.8 dB and maximum 93.5 dB. The dominant factor that has statistically significant association with blood pressure are BMI. This confounding effect of noise intensity can be caused because of noise intensity are vary in each workshop and does not distribute normally. There are still workers that exposed with high intensity noise hazard that may contribute to high blood pressure in the future. It's also recommended to obtain work stress data to see if there are association with the noise hazard there. With this finding intervention should be given to them as part of occupational health primary prevention to control noise and heat hazard such as job rotation, hydration and PPE. It's also important to inform them the importance of healthy lifestyle to maintain ideal body weight such as diet and physical activity, and check blood pressure regularly at the village's health centre.

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