Workplace Noise Pollution and It's Correlation with Hypertension: A Meta-Analysis

Muna Maimunah Salsabila[1], Bhisma Murti[1], Sumardiyono[2]

[1]Masters in Public Health, Universitas Sebelas Maret
[2]Faculty of Medicine, Universitas Sebelas Maret

ABSTRACT

Background: Noise is identified as one of the most widespread physical factors in occupational health and safety (OHS) and is a problem in all regions of the world. Noise can be pathogenic if there is continuous and repeated exposure causing a persistent upregulation of vascular autoregulation resulting in hypertension. Epidemiological studies report an association between occupational noise exposure and hypertension. This study aims to determine the effect of noise exposure in the workplace on hypertension.

Subjects and Method: This study is a systematic review and meta-analysis with the following PICO, Population= workers, Intervention= occupational noise exposure ≥85 dBA, Comparison= occupational noise exposure <85 dBA, Outcome= hypertension. The meta-analysis was carried out using search articles from databases such as Google Scholar, PubMed, and Science Direct, published from 2012 to 2022. The keywords used in the article search were "Occupational Noise Exposure" OR "Occupational Noise" AND "Hypertension" OR "High Blood Pressure" OR "Primary Hypertension" AND "Workers" AND "Cross-Sectional Study". The included studies were full-text articles published in English, reporting the adjusted odds ratio (aOR) of the results of the multivariate analysis, and the study design was cross-sectional. The selection of articles was carried out using PRISMA flow-charts and analyzed using the Revie Manager 5.3 application.

Results: A total of 10 cross-sectional studies were analyzed involving 12,437 workers covering Iran, Jordan, China, Indonesia, Tunisia, and Brazil. The results of the meta-analysis showed that workers exposed to noise 85 dBA had higher hypertension than workers exposed to noise <85 dBA (aOR= 1.96; 95% CI= 1.68 to 2.29; p< 0.001).

Conclusion: Exposure to occupational noise ≥ 85 dBA increases hypertension compared to exposure to occupational noise <85 dBA.

Keywords: occupational noise, noise exposure, hypertension, meta-analysis

Correspondence:
Muna Maimunah Salsabila. Masters' Program in Public Health, Universitas Sebelas Maret, Jl. Ir. Sutami 36A, Surakarta 57126, Central Java, Indonesia. Email: munamaimunahs@gmail.com. Mobile: +6285728565926.

BACKGROUND

Noise is identified as one of the most widespread physical factors in occupational health and safety (OHS) and is a problem in all regions of the world (Zhou et al., 2019; Indriyanti et al., 2019). Noise is all un-wanted sound that comes from production process tools and/or work tools which at a certain level can cause hearing loss (Kemenaker, 2018). Exposure to high levels of work noise can pose risks to health both physically and psychologically (Zainudin, et

al., 2020) such as hearing loss, cardiovascular and circulatory diseases, stress (Sheppard et al., 2020), impaired performance cognitive, and sleep disorders (Basner et al., 2014).

Research conducted by Kerns et al. (2018) regarding cardiovascular conditions, hearing difficulties, noise exposure in industry and work in the United States that 25% of workers who reported having been exposed to noisy work, of which 14% were exposed in the last 12 months with a prevalence of 12% of workers experiencing hearing loss, 24% hypertension, 28% high cholesterol, and 4% CHD (Coronary Heart Disease) or stroke. In addition, research conducted by Sumardiyono et al. (2020) at PT Iskandar Indah Printing Textile Surakarta in the weaving (weaving) section that workers are exposed to noise (8 hours/day), the lowest intensity is 85.4 dBA and the highest is 98.4 dBA with an average value of 90.4 dBA. Referring to the threshold value (NAV) of the Minister of Manpower No. 5 of 2018, namely the noise intensity received by workers for 8 hours of work/day is 85 dBA.

In addition to causing hearing loss, noise is also associated with an increased risk of cardiovascular disease, namely myocardial infarction, stroke, and hypertension (Kerns et al., 2018). Hypertension is called the silent killer because it often appears without complaints until it develops into a more serious disease (Siyad, 2011). 620 people with a death rate due to hypertension of 427,218 (Kemenkes RI, 2018).

Noise can be pathogenic if there is continuous and repeated exposure causing a continuous upregulation of vascular autoregulation resulting in (Shrestha and Shiqi, 2017). A number of epidemiological studies have considered the association between occupational noise exposure and hyper-

tension with varying results. In the meta-analysis, it is stated that there is a relationship between noise exposure and hypertension as follows 1.81 (95% CI 1.51 to 2.18) (Bolm-Audorff et al., 2020); 2.55 (95% CI: 1.94 to 3.36) (Yang et al., 2018); 1.62 (95% CI: 1.40 to 1.88) (Fu et al., 2017).

Based on this background, researchers are interested in examining the effect of noise exposure in the workplace on hypertension. The data obtained will be analyzed using a systematic review and meta-analysis in an effort to obtain comprehensive results by synthesizing the results of primary studies.

SUBJECTS AND METHOD

1. Study Design
This research is a systematic review and meta-analysis. The articles in the study were searched using databases including Google Scholar, Pubmed, and Science Direct, which were published from 2012 to 2022. The keywords used in the article search were "Occupational Noise Exposure" OR "Occupational Noise" AND "Hypertension" OR "High Blood Pressure " OR "Primary Hypertension" AND "Workers" AND "Cross-Sectional Study".

2. Inclusion Criteria
The inclusion criteria in this study were full-text articles with a cross-sectional study design, reporting adjusted odds ratio (aOR) from the results of multivariate analysis, research subjects were workers, the intervention given was occupational noise exposure ≥85 dBA, and the study outcome was hypertension.

3. Exclusion Criteria
Exclusion criteria in the study were articles published before 2012 and traffic noise.

4. Operational Definition of Variables
The search for articles was carried out by considering the eligibility criteria defined using the PICO model. Population=

workers, Intervention= occupational noise exposure ≥85 dBA, Comparison= occupational noise exposure <85 dBA, Outcome= hypertension

Exposure to work noise is noise that originates during production machines at work for 8 hours of work. The instrument used to measure noise is a Sound Level Meter (SLM) and the measurement scale is continuous which is converted into a dichotomy.

Hypertension is a condition of blood pressure with systolic pressure 140 mmHg and diastolic pressure 90 mmHg in workers at work who are exposed to noise for 8 hours of work in 1 day. The instrument used to measure blood pressure is a sphygmomanometer and the measurement scale is continuous which is converted into a dichotomy.

5. Study Instruments

This research was conducted by following the PRISMA flow diagram guidelines and assessing research quality using the Critical Appraisal Checklist for Cross-sectional Study (CEBM, 2014).

6. Data Analysis

Articles collected using PRISMA flow diagrams were analyzed using Review Manager 5.3 software by measuring effect size and heterogeneity. The results of the analysis are reported in the form of forest plots and funnel plots.

RESULTS

The process of searching for articles through the database can be seen in Figure 1. There were 1,081 articles identified through the database, after double data filtering, 707 articles were obtained. There were 53 articles that were deemed eligible, after which articles were excluded for reasons, a total of 10 articles were included in the synthesis and meta-analysis.
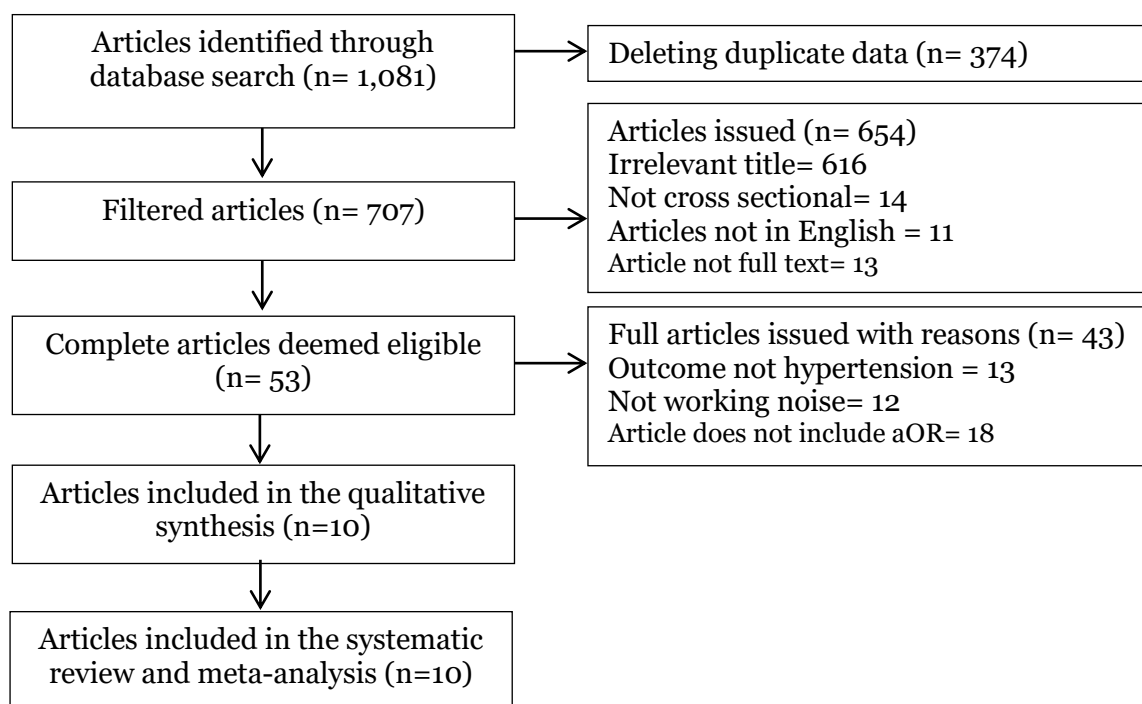

Figure 1. PRISMA Flowchart

Figure 2. Map of study area

Table 1. Assessment of study quality using the Critical Appraisal Checklist for Cross-sectional published by CASP (Critical Appraisal Skills Program)

No	Indicator	Publication (Author and Year)				
		Attarchi et al. (2012)	Nserat et al. (2017)	Shrestha and Shiqi (2017)	Chen et al. (2017)	X. Li et al. (2019)
1	Does the study clearly formulate the research question (research problem)?	2	2	2	2	2
2	Is the research method (study design) appropriate to answer the research question?	2	2	2	2	2
3	Are the methods for selecting research subjects clearly described?	2	2	2	2	2
4	Does the method of obtaining the sample lead to selection bias?	2	2	2	2	1
5	Is the sample representative of the research target population?	2	2	2	2	2
6	Was the sample size estimated taking into account the results of the initial study of statistical power?	1	1	1	2	1
7	Was the minimum response rate reached?	1	1	1	1	1
8	Is the measurement (questionnaire) valid and reliable?	2	2	2	2	2
9	Has statistical significance been tested?	2	2	2	2	2
10	Does the study report confidence intervals?	2	2	2	2	2
11	Are there any confounding factors that have not been taken into account?	0	0	0	0	2
12	Are the results applicable in practice/ community?	2	2	2	2	2
	Total	**20**	**20**	**20**	**21**	**21**

Note: 2: Yes; 1: Hesitant; 0: Can't tell

Table 1. Continue

No	Indicator	Publication (Author and Year)				
		Zhou et al. (2019)	Indriyanti et al. (2019)	Khairani and Achmadi (2020)	Brahem et al. (2019)	de Souza et al. (2015)
1	Does the study clearly formulate the research question (research problem)?	2	2	2	2	2
2	Is the research method (study design) appropriate to answer the research question?	2	2	2	2	2
3	Are the methods for selecting research subjects clearly described?	2	2	2	2	2
4	Does the method of obtaining the sample lead to selection bias?	0	1	0	1	1
5	Is the sample representative of the research target population?	2	2	2	2	2
6	Was the sample size estimated taking into account the results of the initial study of statistical power?	2	1	2	1	1
7	Was the minimum response rate reached?	2	1	2	1	1
8	Is the measurement (questionnaire) valid and reliable?	2	2	2	2	2
9	Has statistical significance been tested?	2	2	2	2	2
10	Does the study report confidence intervals?	2	0	2	2	2
11	Are there any confounding factors that have not been taken into account?	0	0	0	0	0
12	Are the results applicable in practice/community?	2	2	2	2	2
	Total	**20**	**17**	**20**	**19**	**19**

Note: 2: Yes; 1: Hesitant; 0: Can't tell

Table 2. Description of the primary studies included in the meta-analysis primary studies

No	Author (Year)	Country	Study Design	Sample	P (Population)	I (Intervention)	C (Comparisons)	O (Outcome)	aOR (95%CI)
1	Attarchi et al. (2012)	Iran	Cross sectional	331 employees	Workers in the tire industry with more than 1 year of work experience	Noise exposure ≥ 85 dBA	Noise exposure < 85 dBA	Hypertension	4.80 (1.41 to 13.25
2	Nserat et al. (2017)	Jordan	Cross sectional	191 employees	Workers in 3 industries in Madaba, Jordan	Noise exposure > 85 dBA	Noise exposure 85 dBA	Hypertension	4.7 (1.6 to 13.8)
3	Shrestha and Shiqi (2017)	China	Cross sectional	274 employees	Steel industry workers in Guangzhou	Noise exposure > 90 dB	Noise exposure < 80 dB	Hypertension	1.84 (1.35 to 2.51)
4	Chen et al. (2017)	China	Cross sectional	2.789 employees	Workers in the mechanical equipment and household appliances, steel construction, and cigarette manufacturing industries in Hangzhou City	Noise exposure > 80 dB - 95 dB	Not exposed to noise	Hypertension	1.941 (1.471 to 2.561)
5	X. Li et al. (2019)	China	Cross sectional	5.205 employees	Industrial workers in Nanjing City, China	Noise exposure > 85 dB(A)	Noise Exposure <85 dB(A)	Hypertension	1.69 (1.11 to 2.56)
6	Zhou et al. (2019)	China	Cross sectional	1.559 employees	Steel industry worker in Guangzhou, China	Exposure to high noise	Not exposed to noise	Hypertension	2.03 (1.15 to 3.58)
7	Indriyanti et al. (2019)	Indonesia	Cross sectional	104 employees	All workers at PT. X	Noise exposure 85 dBA	Noise exposure < 85 dBA	Increased blood pressure	19.89 (3.35 to 118.13)
8	Khairani and Achmadi (2020)	Indonesia	Cross sectial	51 employees	Workers at PT. X	Noise exposure ≥ 85 dBA	Noise exposure < 85 dBA	Hypertension	7.54 (1.40 to 40.61)
9	Brahem et al. (2019)	Tunisia	Cross sectional	240 employees	Workers in the gas and electricity industry (STEG) in Sousse, Tunisia.	Average noise exposure 89 dB	Not exposed to noise	Hypertension	4.08 (1.39 to 11.95)
10	de Souza et al. (2015)	Brazil	Cross sectional	1.729 employees	Petrochemical and gas sub-contractor in Rio de Janeiro, Brazil	Noise exposure ≥ 85 dBA	Noise exposure ≤ 75 dBA	arterial hypertension	1.58 (1.10 to 2.26)

Study or Subgroup	log[Odds Ratio]	SE	Weight	Odds Ratio IV, Fixed, 95% CI	Odds Ratio IV, Fixed, 95% CI
Attarchi 2012	1.5686	0.625	1.6%	4.80 [1.41, 16.34]	
Brahem 2019	1.4049	0.5491	2.0%	4.08 [1.39, 11.95]	
Chen 2017	0.6632	0.1415	30.3%	1.94 [1.47, 2.56]	
de Souza 2015	0.4574	0.1848	17.8%	1.58 [1.10, 2.27]	
Indriyanti 2019	2.9906	0.9088	0.7%	19.90 [3.35, 118.13]	
Khairani and Achmadi 2020	2.0202	0.8591	0.8%	7.54 [1.40, 40.61]	
Nserat 2017	1.5476	0.5498	2.0%	4.70 [1.60, 13.81]	
Shrestha and Shiqi 2017	0.6098	0.158	24.3%	1.84 [1.35, 2.51]	
X.Li 2019	0.5247	0.2145	13.2%	1.69 [1.11, 2.57]	
Zhou 2019	0.708	0.2899	7.2%	2.03 [1.15, 3.58]	
Total (95% CI)			**100.0%**	**1.96 [1.68, 2.29]**	

Heterogeneity: Chi² = 17.34, df = 9 (P = 0.04); I² = 48%
Test for overall effect: Z = 8.64 (P < 0.00001)

Paparan Kebisingan <85 dB   Paparan Kebisingan ≥85 dB
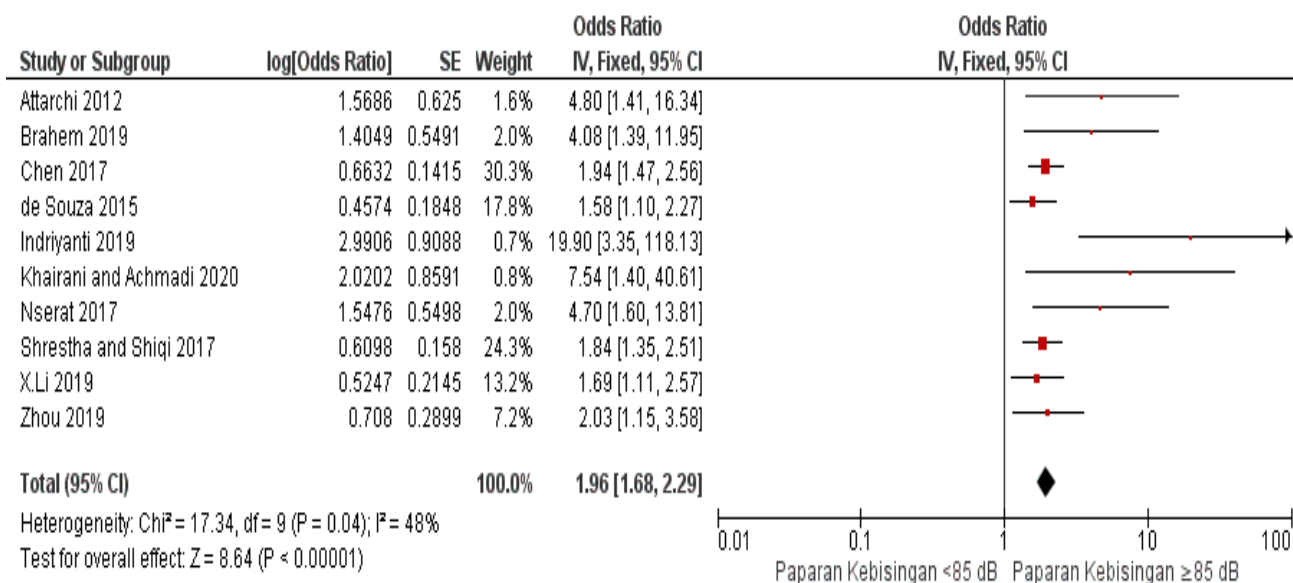
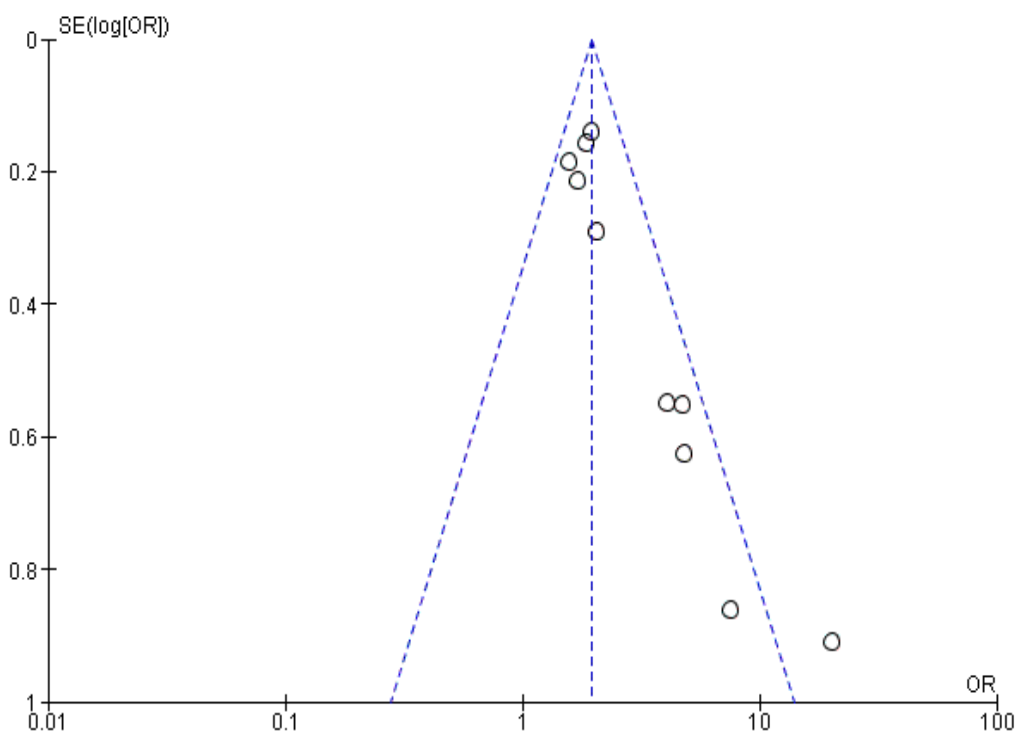**Figure 3. Forest plot meta-analysis of noise Exposure at work against hypertension**

Figure 4. Funnel plot of the effect of noise exposure at work against hypertension

Based on Figure 3. the forest plot results show that workers exposed to noise 85 dB had hypertension as much as 1.96 times compared to workers exposed to noise <85 dB and the results were statistically significant (aOR= 1.96; 95% CI= 1.68 to 2.29; p< 0.001). The heterogeneity of the research data shows I²= 48% so that the distribution of the data is declared homogeneous (fixed effect model).

The funnel plot in Figure 4. shows publication bias with an overestimated effect characterized by the distribution between the right and left plots. There are 5 plots on the right, 2 plots on the left, and 3 plots touching the vertical line. The plot on the right of the graph has a standard error (SE) between 0 and 1. The plot on the left of the graph has a standard error (SE) between 0 and 0.4.

DISCUSSION

This study is a systematic review and meta-analysis with the theme of the effect of noise exposure at work on hypertension. This study discusses the intervention of occupational noise exposure 85 dB to hypertension in workers, this is considered important because noise is a physical factor that can cause occupational diseases, one of which is hypertension which is a silent killer.

Noise is a disturbing sound where workers in industry are potentially exposed to noise. Maximum noise exposure is 8 hours per day with a maximum intensity of 85 dB (Ministry of Manpower, 2018). If the noise generated by industrial equipment exceeds the threshold value and workers are in the area continuously for more than 8 hours with a noise intensity >85 dB, it has the potential to interfere with health. According to Zhou et al., (2019) that continous and repeated exposure to noise can be pathogenic, leading to increased vascular autoregulation that can lead to hypertension.

These results are also in line with research conducted by Indriyanti et al., (2019) on 104 workers showing that workers exposed to noise of more than 85 dB had a 19.8 greater risk of hypertension compared to those exposed to noise <85 dB. In addition, research conducted by Li et al. (2015) on 3150 workers in a steel factory

in Zhengzhou, China showed that workers were exposed to noise with a cumulative intensity of 95 dB to 113 dB with a prevalence of hypertension in 29.88% of men and 12.13% of women. Research Attarchi et al. (2012) and Kalantary et al. (2015) stated that workers exposed to noise experienced an increase in blood pressure.

Noise that exceeds the threshold value can be responded by the body as a stress response. A study on textile workers showed that exposure to noise can increase levels of stress hormones which continously have implications for hypertension (Sumardiyono et al., 2020). The stress response mechanism due to noise that is felt by the body can occur through 2 pathways, namely the direct pathway and the indirect pathway. The direct pathway is a direct interaction between the central auditory nervous system and the central nervous system (CNS) so that it can directly cause ear disorders such as hearing loss to deafness. While the indirect pathway is an emotional reaction in the form of discomfort, sleep disturbances, dizziness, chest palpitations, and an increase in heart rate (Putra, et al., 2020)

The noise intensity in the primary study averaged 85 dB. In the study of Brahem et al. (2019) showed that the mean noise 89 dB had a higher prevalence of hypertension in the exposed group (21.7%) than the unexposed group (5.8%) with an aOR= 4.075 (95% CI= 1.39 to 11.95). These results are in line with the research by Parameswarappa and Narayana (2015) on the steel industry in India, examining 362 workers who were exposed to noise with an intensity of 91 to 102 dB. That workers exposed to high intensity noise had a hypertension prevalence of 35.5% compared to workers exposed to low intensity or intermittent noise (21.7%) with p< 0.05. High noise can increase the risk of patho-

logy by 40% every 5 dB interval (Bluhm et al., 2007).

In addition, the cohort study conducted by Chang et al. (2013) for 10 years in male workers in the aircraft manufacturing industry in Taiwan showed that there was an average increase in systolic and diastolic blood pressure after subjects exposed to noise with an intensity of 85 dBA had a risk of hypertension 1.93 times greater than workers exposed to noise with an intensity of 85 dBA. 85 dBA (ARR= 1.93; 95% CI= 1.15 to 3.22). The meta-analysis study by Bolm-Audorff et al. (2020) which analyzed 24 epidemiological studies showed a significantly increased risk of hypertension due to exposure to noise >80 dB(A) with RR = 1.72 (95% CI = 1.48 to 2.01). The meta-analysis study conducted by Fu et al. (2017). in 32 studies (5 cohort studies, 1 case control study, and 26 cross-sectional studies) also showed that a work environment with noise exposure increased the risk of hypertension with OR= 1.62 (95% CI= 1.40 to 1.88).

Hypertension is called the silent killer because it often appears without complaints until it develops into more serious diseases such as stroke, coronary heart disease, kidney failure, and even death (Siyad, A, 2011; Nuraini, 2015). However, hypertension in workers can be prevented, therefore it is necessary to control noise in the workplace and promote health related to hypertension by the company.

The limitations of this study are search bias because it only uses 3 databases and language bias because it only uses English articles.

The conclusion in the study that noise exposure 85 dB increased hypertension compared to noise exposure <85 dB. Recommendations for further research are expected to use a wider scope (subject, country, study design, and language in the article). Companies are expected to make noise mapping and control noise according to the control hierarchy. The company's health workers are expected to carry out pre-employment medical check-ups, health checks at least once a year, and carry out health promotions related to occupational diseases, especially hypertension.

AUTHORS CONTRIBUTION

Muna Maimunah Salsabila is the main researcher who selects the topic, searches for, and collects research data. Bhisma Murti and Sumardiyono played a role in analyzing and analyzing research data.

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CONFLICT OF INTEREST

Nil.

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