Meta Analysis – Effect of Occupational Noise on the Risk of Hypertension and Noise Induced Hearing Loss in Industrial Workers

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ABSTRACT

Background: Noise is defined as sound intensity that is unwanted and can pose risks to health and safety at work, such as the risk of hypertension and noise-induced hearing loss. This study aims to analyze the effect of occupational noise on the risk of hypertension and noise induced hearing loss in industrial workers.

Subjects and Method: A systematic review and meta-analysis was carried out using the PRISMA guidelines and the PICO model. Population: industrial workers. Intervention: occupational noise exposure ≥85 dB. Comparison: occupational noise exposure <85 dB. Outcome: hypertension and noise induced hearing loss. Articles are collected from PubMed, Science Direct, and Google Schoolar. The keywords used "occupational noise and hypertension" OR "occupational noise and hearing loss" AND "occupational noise" OR "hypertension" AND "hearing loss" AND "cross sectional study". A total of 13 articles met the inclusion criteria, namely primary full text paper, cross-sectional study design, with a relationship size adjusted Odds Ratio (aOR), labor research subjects, interventions in the form of exposure to noise ≥85 dB and outcomes in the form of hypertension and noise induced hearing loss for meta-analyses were then assessed using RevMan 5.3.

Results: Meta-analysis included 13 cross sectional studies from China, Brazil, Ethiopia, Jordan, South Africa, Thailand, Kuwait, and Pakistan. Occupational noise ≥85 dB significantly increased the risk of hypertension (aOR= 2.07; 95% CI= 1.31 to 3.26; p= 0.002) and hearing loss (aOR= 1.97; 95% CI= 1.36 to 2.85; p= 0.003) than occupational noise <85 dB.

Conclusion: Occupational noise ≥85 dB increases the risk of hypertension and hearing loss in industrial workers.

Keywords: occupational noise, hypertension, hearing loss, workers

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BACKGROUND

The scale of processing and manufacturing activities that use technology is increasingly needed because increasingly sophisticated technological developments will simplify and speed up production activities in facto-

ries and ease the work of workers. However, unwittingly, these technological advances have not been matched by efforts to prevent occupational diseases, one of which is the risk of hypertension and hearing loss or noise induced hearing loss that can be experienced by workers due to exposure to noise in the workplace for a long period of time. High levels of occupational noise exposure pose significant risks to health, safety, hearing loss, and hypertension (Feder et al., 2017).

Noise is all unwanted sounds originating from production equipment or work tools which at a certain level will cause hearing loss (Permenaker, 2011). Noise induced hearing loss can occur when parts of the ear do not work normally and this can occur in the outer ear, middle ear, inner ear, auditory nerve (acoustic) and auditory system (NIDCD, 2022). Prolonged or repeated sound exposure at ≥85 dBA can cause hearing loss. the louder the sound, the shorter the time it takes for Noise Induced Hearing Loss to occur (NIDCD, 2022).

In addition to affecting hearing, noise is also associated with an increased risk of cardiovascular disease, namely myocardial infarction, stroke and hypertension. Hypertension is a vascular disease, known as the silent killer because it is often asymptomatic or without complaints. Continuous and repeated exposure to noise can be pathogenic, leading to a continuous upsurge of vascular automatic regulation causing hypertension (Indriyanti et al, 2019).

The highest risk of occupational noise exposure and hearing loss is experienced by construction workers. 76% of US mining workers are exposed to noise. In addition, as much as 55% of wood and manufacturing workers are exposed to noise in the workplace. In Germany, 4 to 5 million people (12 to 15% of the workforce) are exposed to noise levels defined as hazardous by WHO.

In the United States, noise-induced hearing loss (NIHL) accounts for approximately 11% of all occupational diseases. High levels of occupational noise exposure pose significant risks to occupational health and safety (Feder et al., 2017).

Based on a study, it shows that there is a significant relationship between noise intensity and the incidence of hypertension in PT. Kondang Buana Asri in 2020 where 63.9% were exposed to noise >85 dB experienced pre-hypertension, 19.4% experienced normal hypertension and 16.7% experienced stage 1 hypertension. For workers exposed to noise ≤85 dB of which 50% have normal hypertension and 50% have pre-hypertension. This could be because working in a noisy environment that exceeds the threshold value of >85 dB for 8 hours without using ear protection can affect the workforce's hearing system besides that it also triggers emotional instability (Hamdie et al, 2020).

These conditions indicate that exposure to noise ≥85 dB in the workplace has the potential to experience hypertension and noise induced hearing loss in industrial workers. Therefore, there is a need for more thorough research than the results of various previous primary studies. Various primary research results were combined in a meta-analytic research design using the RevMan 5.3 application to measure the magnitude of the influence so that a quantitative summary of the results was obtained (Murti, 2018). The purpose of this study was to analyze the effect of occupational noise on the risk of hypertension and noise induced hearing loss in industrial workers based on the results of previous similar studies.

SUBJECTS AND METHOD

1. Study Design

This study uses a systematic review and meta-analysis method, which is a way of

analyzing data derived from primary studies from databases based on PRISMA diagrams. Search for articles in this study using electronic databases such as PubMed, Science Direct, and Google Scholar. The keywords used in the database search were "occupational noise and hypertension" OR "occupational noise and hearing loss" AND "occupational noise" OR "hypertension" AND "hearing loss" AND "cross sectional studys".

2. Steps of Meta-Analysis

The meta-analysis was carried out through 5 steps as follows:

1) Formulate research questions using PICO model. Population= health worker. Intervention= occupational noise exposure ≥85dB. Comparison= occupational noise exposure <85dB. Outcome= hypertension and noise induced hearing loss.

2) Search for primary study articles from electronic databases such as PubMed, Science Direct, and Google Scholar.

3) Conduct screening and conduct critical appraisal of primary studies.

4) Perform data extraction and enter effect estimates from each primary study into the RevMan 5.3 application. The results of the article analysis are presented in the form of an overall aOR, describing the 95% confidence interval (CI) using effect models and data heterogeneity (I^2).

5) Interpret results and draw conclusions

3. Inclusion Criteria

Inclusion criteria in this study were full text paper primary research articles using a cross-sectional study design, multivariate analysis with adjusted odds ratio (aOR), labor study subjects, interventions in the form of exposure to noise ≥85 dB and outcomes in the form of hypertension and noise induced hearing loss.

4. Exclusion Criteria

Research articles published before 2013 and after 2023, noise originating from traffic because in this study using noise originating from the workplace and research articles published other than English.

5. Operational Definition of Variables

Exposure to occupational noise: is continuous noise coming from work machines or production equipment at work for 8 hours of work.

Hypertension: is a condition where the blood pressure is systolic ≥140 and/or diastolic ≥90 mmHg in workers in the workplace who are exposed to noise for 8 working hours per day or 40 hours per week.

Noise induced hearing loss: is hearing loss due to exposure to noise in a work environment for a long time and continuously.

6. Study Instruments

This research was conducted using the PRISMA flow-chart guidelines and the quality assessment in this study used the 2018 Critical Appracial Skills Program (CASP).

7. Data Analysis

Data processing was carried out using the RevMan 5.3 application by calculating effect size and heterogeneity to determine the combined research model and form the final results of the meta-analysis.

RESULTS

The process of searching articles in this meta-analysis is by searching through databases, namely PubMed, Science Direct, and Google Scholar with a time span between 2013 to 2022. The article search process was in accordance with PRISMA. flow diagram can be seen as follows.

The Figure 1 shows the initial search process which displays a total of 1,095 articles. After the process of deleting articles that were duplicated in more than one journal, 726 articles were obtained, of which 63 met the requirements for further full text review. Then there were 13 articles that met the requirements for a full text review. which are spread over 3 continents, namely Asia, Africa, and America (Figure 2).
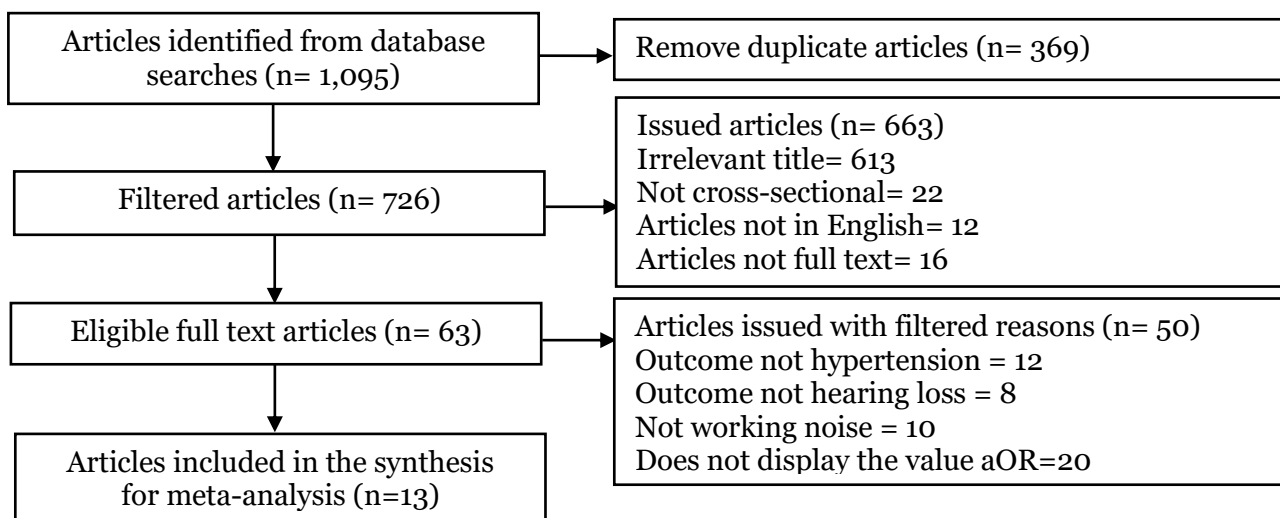
Figure1. PRISMA Flow Diagram

Figure 2. The research area study of the effect of occupational noise on the risk of hypertension and noise induced hearing loss in industrial workers

Table 1. Results of Critical Appraisal on the effect of occupational noise on the risk of hypertension and noise induced hearing loss in industrial workers

Primary Study	Criteria of Questions								Total
	1	2	3	4	5	6	7	8	
Sriopas et al. (2017)	2	2	2	2	2	2	2	2	16
Li et al. (2019)	2	2	2	2	2	1	2	2	15

Primary Study	Criteria of Questions								Total
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	
Melese et al. (2022)	2	2	2	2	2	2	2	2	16
Buqammaz et al. (2021)	2	2	2	2	2	2	2	2	16
Almaayeh et al (2018)	2	2	2	2	1	2	2	2	15
Wang et al. (2013)	2	2	2	2	2	2	2	2	16
Melese et al (2023)	2	2	2	2	2	1	2	2	15
de Souza et al. (2015)	2	2	2	2	2	2	2	2	16
Nserat et al. (2017)	2	2	2	2	2	2	2	2	16
Shahid et al. (2018)	2	2	2	2	2	1	2	2	15
Kubheka (2019)	2	2	2	2	2	1	2	2	15
Liu et al. (2016)	2	2	2	2	2	2	2	2	16
Chen et al. (2017)	2	2	2	2	2	2	2	2	16

Description of the question criteria:
1 = Were the inclusion criteria in the study explained in detail?
2 = Are the objects and locations of the research described in detail?
3 = Is the exposure variable measured validly and reliably?
4 = Are clear standard criteria used in measuring variables?
5 = Is there any confounding in the research?
6 = How to overcome these confounding factors?
7 = Are the outcomes measured validly and reliably?
8 = Was the data analysis done properly?

Description of the answer score:
0 = No
1 = Can't tell
2 = Yess

Table 2. Description of the cross-sectional study of the effect of occupational noise on the risk of hypertension and noise induced hearing loss in industrial workers (N= 23,460)

| Author (year)	Country	Sample size	P	I	C	O
Li et al. (2019)	China	6,048	Coal industry workers	Exposure to noise	Not exposed to noise	Hypertension and Hearing Loss
Liu et al. (2016)	China	738	Manufacturing industry workers	Exposure to noise	Not exposed to noise	Hypertension
de Souza et al. (2015)	Brazil	1,729	petrochemical industry workers	Exposure to noise ≥85 dB	Exposure to noise ≥85 dB	Hypertension
Melese et al. (2023)	Ethiopia	300	Metal industry workers	Exposure to noise ≥85 dB	Exposure to noise ≥85 dB	Hypertension
Chen et al. (2017)	China	2,789	Manufacturing industry workers	Exposure to noise	Not exposed to noise	Hypertension
Wang et al. (2013)	China	728	Automobile industry workers	Exposure to noise ≥85 dB	Exposure to noise ≥85 dB	Hypertension

Author (year)	Country	Sample size	P	I	C	O
Nserat et al. (2017)	Jordan	191	Manufacturing industry workers	Exposure to noise ≥85 dB	Exposure to noise ≥85 dB	Hypertension
Khubeka (2021)	South Africa	299	Steam power industry workers	Exposure to noise ≥85 dB	Exposure to noise ≥85 dB	Hearing loss
Sriopas et al. (2017)	Thailand	356	Auto parts industry workers	Exposure to noise ≥85 dB	Exposure to noise ≥85 dB	Hearing loss
Buqammaz et al. (2021)	Kuwait	3,474	Manufacturing industry workers	Exposure to noise	Not exposed to noise	Hearing loss
Shahid et al. (2018)	Pakistan	264	Textile industry workers	Exposure to noise ≥85 dB	Exposure to noise ≥85 dB	Hearing loss
Melese et al. (2022)	Ethiopia	300	Metal industry workers	Exposure to noise ≥85 dB	Exposure to noise ≥85 dB	Hearing loss
Almaayeh et al. (2018)	Jordan	196	Manufacturing industry workers	Exposure to noise ≥85 dB	Exposure to noise ≥85 dB	Hearing loss

Table 3. Adjusted Odds Ratio (aOR) effect of work noise on hypertension risk (N= 12,523)

Author (Year)	aOR	95%CI	
		Lower Limit	Upper Limit
Li et al. (2019)	1.31	0.97	1.79
Liu et al (2016)	1.03	1.01	1.06
De Souza et al. (2015)	1.58	1.10	2.26
Melese et al. (2023)	3.8	2.8	5.9
Chen et al. (2017)	1.94	1.47	2.56
Wang et al. (2013)	3.56	1.98	6.39
Nserat et al. (2017)	4.7	1.6	13.8

Table 3 shows the aOR value related to the effect of occupational noise on the risk of hypertension in industrial workers. The highest aOR value was in the study by Nserat et al. (2017) (aOR=4.7; 95% CI= 1.6 to 13.9) and the lowest aOR value in the study of Li et al. (2019) (aOR= 1.31; 95% CI= 0.97 to 1.79).
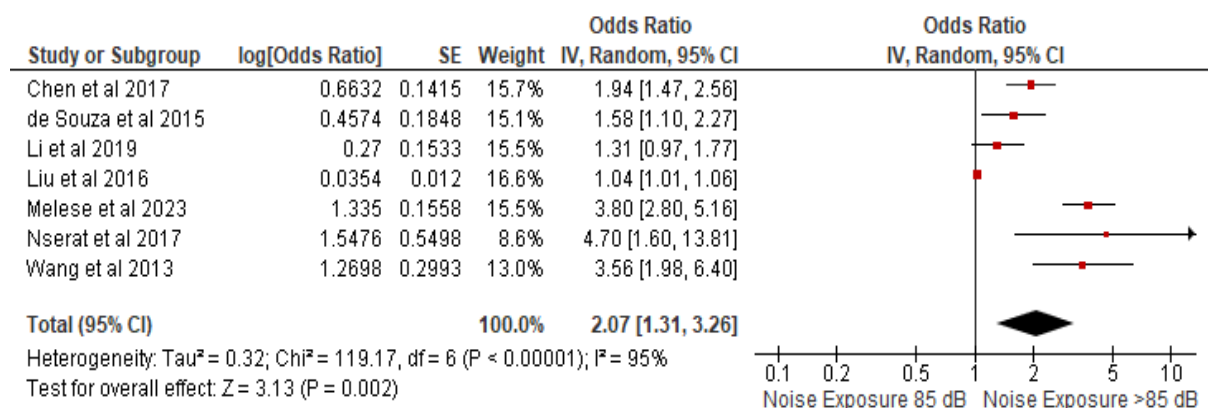
Figure 3. Forest plot of the effect of occupational noise on the risk of hypertension in industrial workers

The forest plot in Figure 3 shows that work noise has an effect on the risk of hypertension in industrial workers. Workers who were exposed to noise ≥85 dB at work were 2.07 times at risk for hypertension compared to workers not exposed and its statistically significant (OR= 2.07; 95% CI= 1.31 to 3.26; p= 0.002). The forest plot also shows high heterogeneity of effect estimates between primary studies (I²= 95%; p= 0.001). The calculation of the average effect estimate was carried out using the random effect model approach.
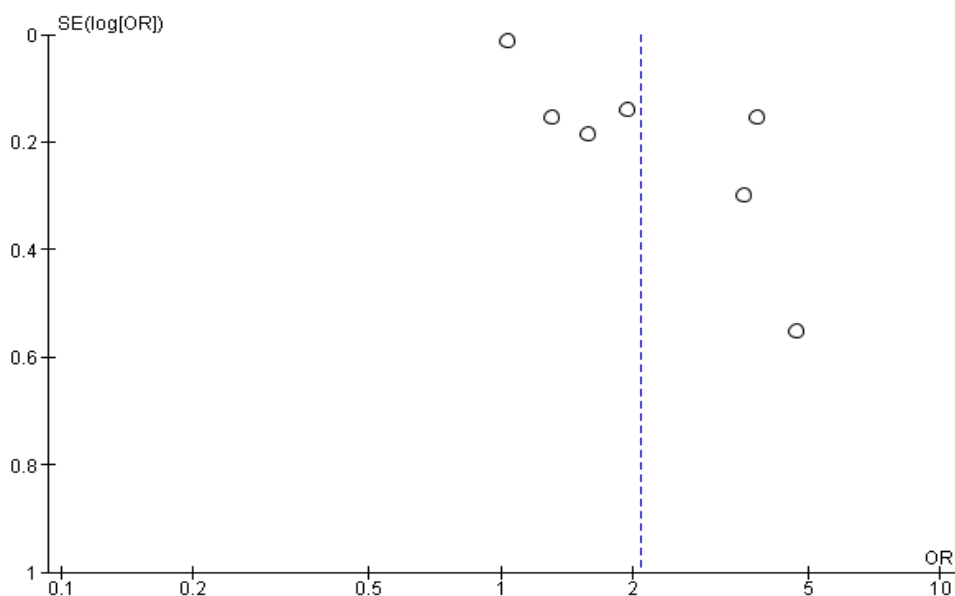
Figure 4. Funnel plot of the effect of occupational noise on the risk of hypertension in industrial workers

The funnel plot in Figure 4 shows that the distribution of estimates between studies is asymmetric, namely the distribution o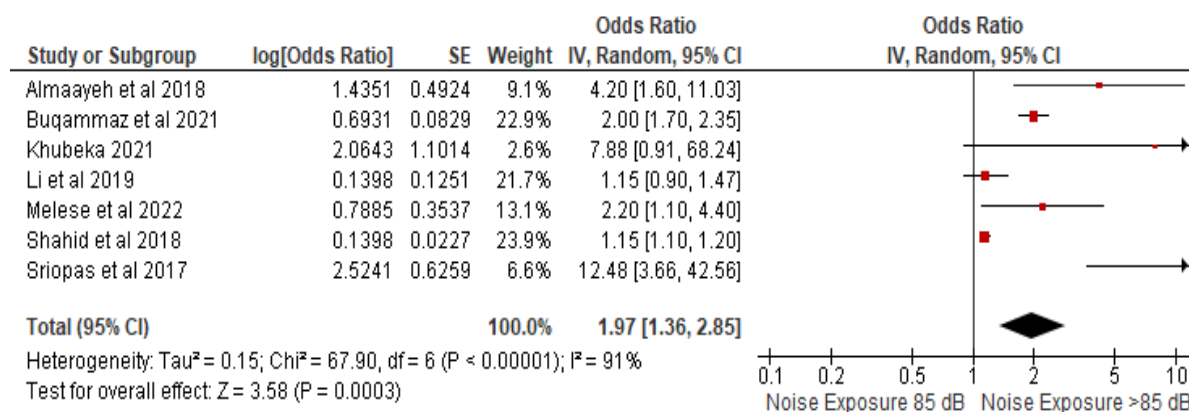r distribution of effect estimates to the left of the vertical line of the average effect estimates is relatively larger than to the right (overestimate). Thus this funnel plot indicates publication bias

Table 5. Adjusted Odds Ratio (aOR) effect of occupational noise with noise induced hearing loss (N= 10.937)

Author (Year)	aOR	95 % CI	
		Lower limit	Upper limit
Li et al. (2019)	1.15	0.90	1.47
Khubeka (2021)	7.88	0.91	68.43
Sriopas et al. (2017)	12.48	3.66	42.54
Buqammaz et al. (2021)	2.0	1.7	2.4
Shahid et al. (2018)	1.15	1.10	1.30
Melese et al. (2022)	2.2	1.1	6.5
Almaayeh et al. (2018)	4.2	1.6	10.5

Table 4 shows that seven articles display-ed aOR values related to the effect of occupational noise with noise-induced hearing loss in industrial workers. The highest aOR value was in study by Sriopas et al. (2017) with (aOR= 12.48; 95% CI = 3.66 to 42.54) and the lowest aOR value in the study of Li et al. (2019) with (aOR= 1.15; 95% CI= 0.90 to 1.47) and Shahid et al. (2018) with (aOR= 1.15; 95% CI= 1.10 to 1.30).

Study or Subgroup	log[Odds Ratio]	SE	Weight	Odds Ratio IV, Random, 95% CI
Almaayeh et al 2018	1.4351	0.4924	9.1%	4.20 [1.60, 11.03]
Buqammaz et al 2021	0.6931	0.0829	22.9%	2.00 [1.70, 2.35]
Khubeka 2021	2.0643	1.1014	2.6%	7.88 [0.91, 68.24]
Li et al 2019	0.1398	0.1251	21.7%	1.15 [0.90, 1.47]
Melese et al 2022	0.7885	0.3537	13.1%	2.20 [1.10, 4.40]
Shahid et al 2018	0.1398	0.0227	23.9%	1.15 [1.10, 1.20]
Sriopas et al 2017	2.5241	0.6259	6.6%	12.48 [3.66, 42.56]
Total (95% CI)			100.0%	1.97 [1.36, 2.85]

Heterogeneity: Tau² = 0.15; Chi² = 67.90, df = 6 (P < 0.00001); I² = 91%
Test for overall effect: Z = 3.58 (P = 0.0003)

Figure 5. Forest plot of the effects of occupational noise with noise induced hearing loss in industrial workers

The forest plot in Figure 5 shows that occupational noise has an effect on noise induced hearing loss in industrial workers. Workers exposed to noise ≥85 dB at work are at risk 1.97 times compared to workers exposed to noise <85 dB with this result being statistically significant (OR= 1.97; 95% CI= 1.36 to 2.85; p= 0.003). The forest plot also shows high heterogeneity of effect estimates between primary studies I^2 = 91%; p= 0.001. Likewise, the calculation of the average effect estimate is carried out using the random effect model approach.
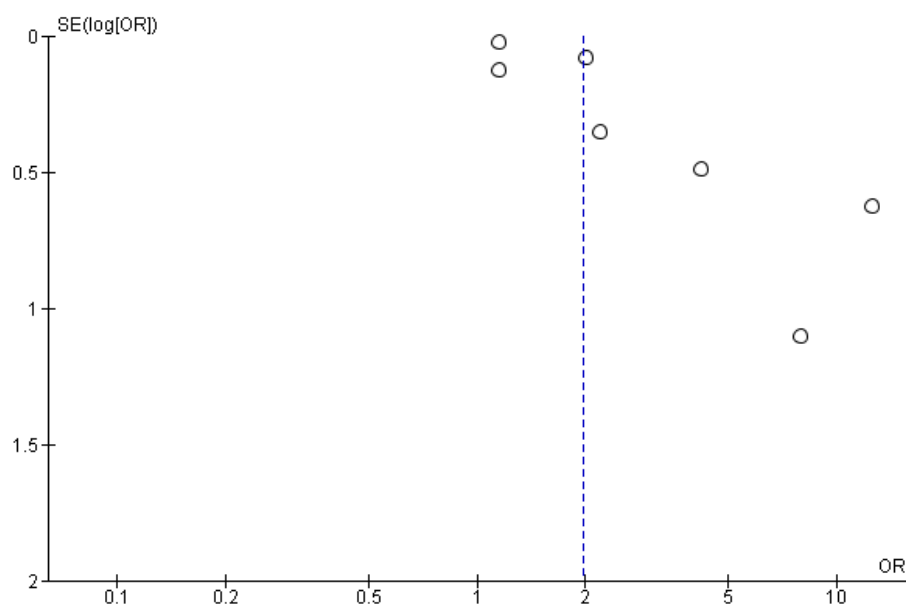
Figure 6. Funnel plot of the effect of occupational noise with noise induced hearing loss in industrial workers

The funnel plot in Figure 6 shows that the distribution of estimates between studies is asymmetric, namely the distribution or distribution of effect estimates to the right of the vertical line of the average effect estimate is relatively larger than to the left (overestimate). Thus this funnel plot indicates publication bias.

DISCUSSION

Systematic review research and meta-analysis in this study themed the effect of occupational noise on the risk of hypertension and noise induced hearing loss in industrial workers. Workers who are continuously exposed to high noise ≥85 dB for a long time are more at risk of experiencing hypertension and hearing loss than workers who are exposed to noise <85 Db (Liu et al., 2016).

1. The effect of occupational noise on the risk of hypertension

Workers who are exposed to noise ≥85dB at work will be more at risk of developing hypertension than workers who are exposed to noise <85 dB. The noise can affect the autonomic nervous system and endocrine system which in turn will affect the homeostasis of the human organism (Malese et al, 2023).

Primary research related to the effect of occupational noise on the risk of hypertension in industrial workers included in this synthetic meta-analysis as many as seven articles were then analyzed using Revman 5.3. Based on the results of the synthesis of the seven primary studies, there was high heterogeneity between experiments (I^2= 95%; p= 0.001), so the analysis used a random effect model. High heterogeneity is due to sample sizes that vary between studies.

Exposure to occupational noise increases the risk of developing hypertension in industrial workers. This result is in accordance with the hypothesis. A meta-analysis of seven cross-sectional articles related to the effect of occupational noise on the risk of hypertension in industrial workers shows that industrial workers exposed to noise ≥85 dB 2.07 have a risk of developing hypertension than workers exposed to noise <85 dB (aOR= 2.07; 95%CI= 1.31 to 3.26; p= 0.002). This meta-analysis uses studies that have controlled for confounding factors, as stated in the inclusion criteria, namely the adjusted odds ratio (aOR).

Liu et al. (2019) who measured the relationship between occupational noise exposure and the risk of hypertension in manufacturing industry workers where workers exposed to high noise ≥85 dB were more at risk of experiencing hypertension than workers exposed to noise <85 dB. This study is in line with research conducted by Nserat et al. (2017) found that there was a significant relationship between exposure to occupational noise ≥85 dB for manufacturing industry workers in developing hypertension (OR= 4.70; CI95%= 1.60 to 13.81; p= 0.001). This result was also supported by Chen et al. (2017) that there is a relationship between occupational noise exposure and the risk of hypertension in manufacturing industry workers (OR = 1.94; 95% CI = 1.47 to 2.56; p= 0.001). Exposure of noise that is greater than the Threshold Value continuously can increase blood cortisol that can impact on increasing systolic and diastolic blood pressure. (Lee et al., 2016). The complication of hypertension can cause coronary heart disease, kidney failure, and stroke which can cause death. Therefore hypertension is referred to as a "silent killer" (Nuraini, 2015).

2. The effect of occupational noise with noise induced hearing loss

One of health problems resulting from exposure to noise is noise induced hearing loss (Salawati, 2013). There is a significant relationship between exposure to noise in the workplace and the occurrence of hearing loss where workers exposed to noise ≥85 dB are 12.48 times more at risk of experiencing hearing loss than workers exposed to noise <85 dB. Other factors that can cause hearing loss are workers who have worked for >10

years and workers who smoke (Sriopas et al., 2017).

Primary research related to the effect of occupational noise with noise induced hearing loss included in this synthetic meta-analysis of 7 articles was then analyzed using Revman 5.3. Based on the results of the synthesis of 10 primary studies, there was high heterogeneity between experiments (I^2= 91%; p= 0.001) so that the analysis used the Random Effect Model (REM).

Occupational noise can increase the occurrence of noise induced hearing loss. This result is in accordance with the hypothesis. A meta-analysis of 7 cross-sectional articles related to effect of occupational noise on noise induced hearing loss shows that exposure to noise ≥85dB can increase 1.97 times the occurrence of noise induced hearing loss in industrial workers compared to industrial workers exposed to noise <85dB (aOR= 1.97; 95%CI= 1.36 to 2.85; p= 0.003). This meta-analysis was also used studies that have controlled cofounding factors, as stated in the inclusion criteria, namely the adjusted odds ratio (aOR).

Khubeka et al. (2021), showed that there was a relationship between work noise and noise induced hearing loss in workers in the steam power industry (aOR= 7.88; 95%CI= 0.91 to 68.24; p= 0.001). This result was also supported by Almaayeh et al. (2018) that there is a relationship between occupational noise exposure and noise induced hearing loss in manufacturing industry workers (OR= 4.20; 95% CI= 1.60 to 11.03; p= 0.003).

Exposure to noise can produce changes in the ciliary hair cells of the organ of Corti. Exposure to high-intensity noise for a long time will damage other cell structures such as mitochondria, lysosomal granules, lys cells and tear the tympanic membrane. Other factors that can exacerbate noise induced hearing loss are noise intensity, noise frequency, length of exposure per day, years of work or length of work, individual sensitivity, age and other factors that can cause deafness (Abraham et al., 2019).

The impact of noise induced hearing loss is that concentration will decrease which is caused by an imbalance in the auditory system between the two ears and difficulties in processing the sound source that is heard. Other impacts are fatigue, headaches because the nerves that function to regulate hearing are not functioning properly, will experience sleep disturbances which is due to the memory system working to try to understand the source of the sound which will eventually lead to loss of work productivity due to the inability to adapt to work standards (Mayasari, 2017).

AUTHOR CONTRIBUTION

Ila Izzatus Salamah as the main researcher who chose the topic, conducted a search for data collection. Bhisma Murti and Sumardiyono who contributed to supervisor in manuscript writing.

CONFLICT OF INTEREST

There is no conflict of interest in this study.

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