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# Effect of Noise Exposure on Occupational Stress and Hypertension Among Workers: A Meta-Analysis

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## ABSTRACT

**Background:** The work environment greatly affects the health condition of the workers so that there are no work-related accidents or occupational diseases. Noisy physical environmental factors above the threshold value have a risk of causing occupational diseases such as psychological work stress and hypertension. This study aims to analyze the effect of noise exposure on occupational stress and hypertension among workers.
**Subjects and Method:** This study is a systematic review and meta-analysis with the following PICO. P: working society, I: exposure noise ≥85 dBA, C: not exposed to noise ≥85 dBA, O: Stress and Hypertension. This study used of articles published between 2009 and 2022 were comprehensively searched for using electronic databases like PubMed, ProQuest, Scopus, and Google Scholar. The keywords to search for articles were "noise exposure" OR "occupational noise" AND "occupational stress" OR "work stress" AND "hypertension". The adjusted odds ratio was used to evaluate the effect size (aOR). To evaluate the bias risk, the Critical Appraisal Skill Program (CASP) was used. Articles were analyzed using the Review Manager 5.3 application.
**Results:** This study includes 14 papers, using cross-sectional and case-control study designs, from Asia, including Indonesia, Malaysia, China, Jordan, and South Korea. Based on 5 studies cross-sectional on the effects of exposure to noise in the event of work stress, work stress increases 4.88 times compared to workers who are not exposed to noise (aOR=4.88; 95% CI= 1.77 to 13.47; p= 0.002). 9 subgroup studies with cross-sectional and case-control study designs on the effect of noise exposure showed an increase of 2.47 times the incidence of hypertension compared to workers who were not exposed to noise at work (aOR= 2.47; 95% CI= 1.75 to 3.48; p<0.001).
**Conclusion:** Exposure to noise increases the risk of work-related stress and hypertension. Suggestions that can be made are to carry out engineering, periodic measurements, work time management, workforce education and use of PPE.

**Keywords:** noise exposure, occupational noise, occupational stress, work stress, hypertension

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## BACKGROUND

World Health Organization (WHO) data, poor working conditions cause an estimated 300,000 deaths in Europe each year and a 4% loss in GDP. 1.6% of the total sickness burden may be attributable to injury, noise, carcinogens, airborne particulate matter, and ergonomic dangers, to identify just a few unfavorable situations. 22% of the burden of occupational diseases were caused by noise concerns. Given that about 22 million American workers are exposed to dangerous occupational noise each year, the scope of the noise problem is significant (Liu et al., 2020).

One of the most frequent workplace hazards is noise. 28% of European workers reported being exposed to loud noise for at least one-fourth of their working hours, with the number varying from 18% in Malta and Portugal to 44% in Turkey, according to the 2015 European Survey on Working Conditions (ECWS). In the USA, 25% of workers with a point prevalence of 14% reported having experienced workplace noise in the past. 34.3% of the 22 million American workers who are said to be subjected to excessive noise at work report they have never worn hearing protection (Kerns et al., 2018; Pretzsch et al., 2021). A complete stress model that explains how psychological stress brought on by noise raises the risk of metabolic, pulmonary, and cardiovascular disorders (Pretzsch et al., 2021; Recio et al., 2016). Continual or frequent stress, according to the general stress model, throws the body out of homeostasis and triggers physiological reactions as well as allostatic load. Repeated or protracted adaptive reactions to stress alter brain circuitry and set off a chain reaction of immunological reactions, which can result in endothelial and mitochondrial dysfunction and elevated blood pressure ((Pretzsch et al., 2021; Marón et al., 2019).

Noise-related stress responses lead to oxidative stress and neuronal nitric oxide synthase downregulation, which serve as a pathomechanism for heart, metabolic, and mental health conditions (Daiber et al., 2020; Pretzsch et al., 2021).

When the demands of the job don't match the employees' abilities, resources, or requirements, it can lead to negative physical and emotional reactions. The effects of work-related stress on one's health and potential for harm. When the demands of the workplace are incompatible with the workers' abilities, resources, or needs, stress at work results (Sarkar et al., 2024). Exposure to loud noise can increase blood pressure in addition to stress at work. One of the most important etiological causes of cardiovascular illnesses is hypertension. There are essentially two ways that noise can raise blood pressure: either by producing stress hormones like steroids or by activating the sympathetic nervous system (Shrestha and Shiqi, 2017).

When workers are exposed to loud noise, Hypertension is comparably prevalent and recognized as one of the common health risks (Liu et al., 2016). There are two physiological explanations for the association between noise and high blood pressure: either the release of stress hormones like steroids or the activation of the sympathetic nervous system, which results in the release of chemicals like adrenaline. One theory for the pathophysiology of noise-induced hypertension is that a malfunctioning stress mechanism is involved (Shrestha and Shiqi, 2017).

Long-term workplace noise exposure has been shown in numerous past studies to cause hypertension. An enhanced risk of hypertension was observed in patients exposed to loud noise for an extended period of time after correcting for age, race, and years of employment. With cumulative noise exposure of 85 dB and above, this danger

kept increasing (Stanovská and Tomášková, 2024). Therefore, this meta-analysis aims to investigate the effect of noise exposure in the workplace on the risk of occupational stress and hypertension in the workplace.

## SUBJECTS AND METHOD

### 1. Study Design

A cross-sectional meta-analysis compared noise exposure in the workplace that exceeds the NAB (≥85dB) with noise exposure below the NAB (<85dB) on occupational stress and hypertension among workers. Publication between 2005 and 2021 from several databased, including Google Scholar, PubMed, ProQuest, and Scopus. Utilizing the PRISMA flow chart, the papers were chosen. The keywords to search for articles were "noise exposure" OR "occupational noise" AND "occupational stress" OR "work stress" AND "hypertension". This meta-analysis was reported according to the PRISMA (Preferred Reporting Items for Systematic Review and Meta-Analyses) guidelines.

### 2. Step of Meta Analysis

1) Use the PICO approach (Population, Intervention, Comparison and Outcome ) to formulate research question.
2) Electronic and non-electrical databased searching such as Google Scholar, PubMed, ProQuest, and Scopus for primary study articles**.**
3) Establish inclusion and exclusion criteria through a screening procedure then conduct comprehensive critical evaluation.
4) RevMan application utilization to construct effect estimates after gathering data form the primary Studies.
5) Conducting interpretation and conclusion from finding and study resultssampling.

### 3. Inclusion Criteria

A full-text publication with a cross-sectional and case-control design, employees exposed to noise as research subjects, job stress and hypertension as research outcomes, and multivariate analysis with adjusted Odds Ratio (aOR) to quantify the expected effect were the inclusion criteria for this study.

### 4. Exclusion Criteria

Articles published in languages other than English or Bahasa, statistical findings presented in the form of bivariate analysis or experimental studi design, and publications from before 2009 were excluded from this research article.

### 5. Operational Definition of Variables

The search of articles was carried out by eligibility criteria determined by PICO Model. P: working society. I: exposure noise-≥85 dBA. C: not exposed to noise≥85dBA. O: Stress and Hypertension. Exposure to noise ≥85 dBA that are heard by worker it their worksite. Noise from production process with long exposure of 8 hours/day. Stress are negative emotional and physical reactions that arise while worker expose to noise ≥85 dBA of 8 hours/day. Hypertension when the pressure in blood pressure were high (140/90 mmHg or Higher) as result from noise exposure ≥85 dBA of 8 hours/ day.

### 6. Study Instruments

This research study is guided by the PRISMA diagram and article quality assessment using the Critical Appraisal Skills Program (CASP, 2018).

### 7. Data Analysis

The study's data were examined using Review Manager tool (RevMan 5.3). The size of the association and the degree of data heterogeneity were assessed using forest plots and funnel plots, respectively. For homogeneous data, the fixed effects model was applied, while for heterogeneous data across studies, the random effects model was applied. The intuitive index (I2), which shows the overall variation among studies (given as a percentage) due to heterogeneity rather than sampling error, was used to statistically quantify the heteroge-

neity between research. Significant heterogeneity is indicated by an I2 score greater than 50%. If an I2 value more than 50% identifies heterogeneity, random-effect analysis models are applied.

## RESULTS

Articles outcome as ilustrated in Figure 1, revealing 847 articles from utilized data bases including PubMed, ProQuest, Scopus, and Google Scholar. Articles published between 2009-2022 were filtered and 29 duplicate article were removed, and 819 articles remained. There were 67 article eligible for the full text and 14 full text articles were meeting the criteria underwent meta analysis.

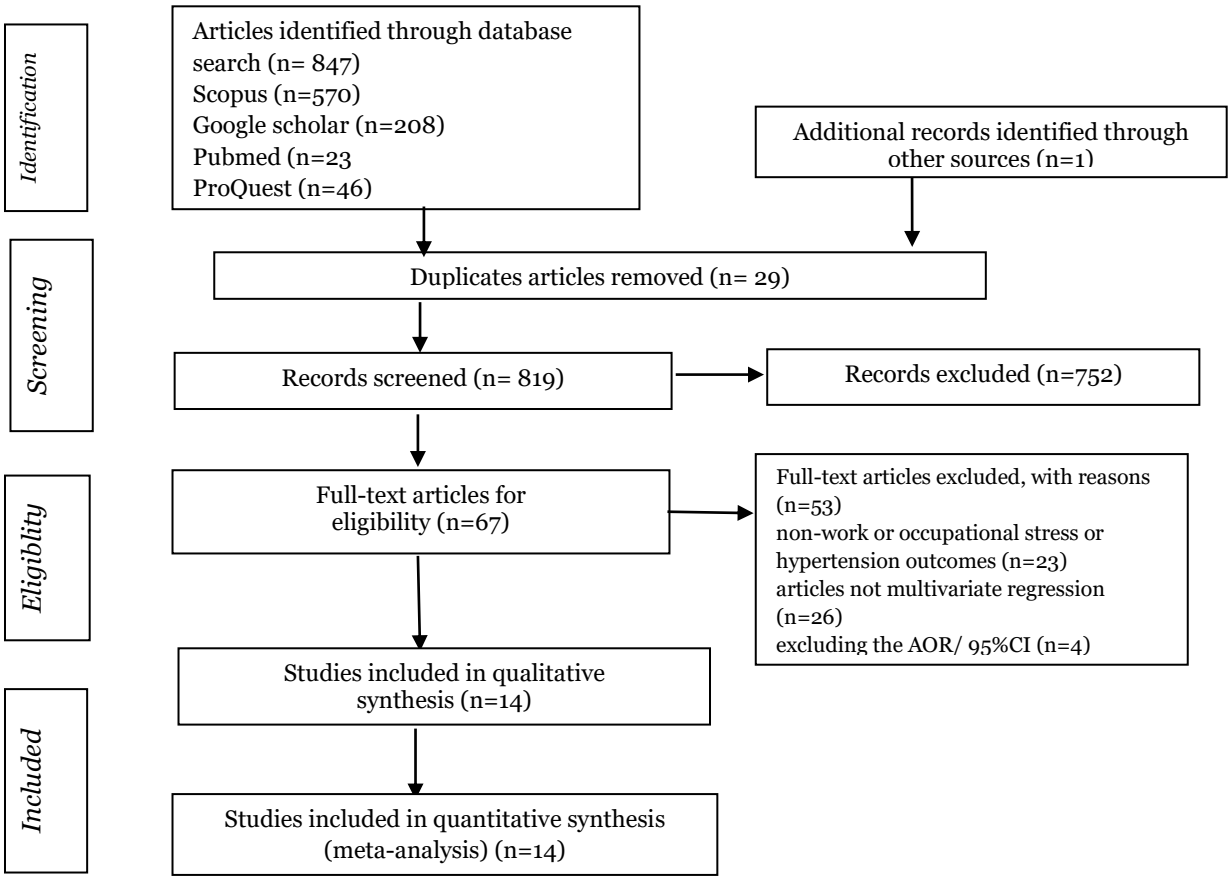


**Figure 1. PRISMA Flowchart**


**Fiure 2. Map of the distribution of articles included in the mata-analysis**

**Tabel 1. Result of the quality Assessment of the cross-sectional study on the effect of noise exposure on occupational stress**

| Authors (year) | Criteria | | | | | | | | | | | | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | |
| Handayani et al. (2016) | 2 | 2 | 2 | 2 | 2 | 1 | 2 | 2 | 2 | 1 | 2 | 2 | 22 |
| Mursali et al. (2009) | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 24 |
| Ningsih and Fitri (2017) | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 24 |
| Nuaim et al. (2015) | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 24 |
| Yanti et al. (2013) | 2 | 2 | 2 | 2 | 2 | 1 | 2 | 2 | 2 | 2 | 2 | 2 | 23 |

Note: 2: Yes; 1: Hesitant; 0: No

**Description of question Criteria**

1 = Does the study clearly formulate the research question (research problem)?
2 = Is the research method (study design) appropriate to answer the research question?
3 = Are the methods for selecting research subjects clearly described?
4 = Does the method of obtaining the sample lead to selection bias?
5 = Is the sample representative of the research target population?
6 = Was the sample size estimated taking into account the results of the initial study of statistical power?
7 = Was the minimum response rate reached?
8 = Is the measurement (questionnaire) valid and reliable?
9 = Has statistical significance been tested?
10 = Does the study report confidence intervals?
11 = Are there any confounding factors that have not been taken into account?

**Tabel 2. Result of the quality assessment on the effect of noise exposure on Hypertension**

| Authors (year) | Criteria | | | | | | | | | | | | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | |
| Shrestha and Shiqi (2017) | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 24 |
| Nserat et al. (2017) | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 24 |
| Khairani dan Achmadi (2020) | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 24 |
| Utami et al. (2020) | 2 | 2 | 2 | 2 | 2 | 1 | 2 | 2 | 2 | 1 | 2 | 2 | 22 |
| Zhou et al. (2019) | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 24 |
| Attarchi et al. (2012) | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 24 |
| Wu et al. (2022) | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 24 |
| Kim and Ahn (2021) | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 1 | 2 | 2 | 2 | 2 | 23 |
| Wang et al. (2018) | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 24 |

Note: 2: Yes; 1: Hesitant; 0: No

**Description of question Criteria**

1 = Does the study clearly formulate the research question (research problem)?
2 = Is the research method (study design) appropriate to answer the research question?
3 = Are the methods for selecting research subjects clearly described?
4 = Does the method of obtaining the sample lead to selection bias?
5 = Is the sample representative of the research target population?
6 = Was the sample size estimated taking into account the results of the initial study of statistical power?

7 = Was the minimum response rate reached?
8 = Is the measurement (questionnaire) valid and reliable?
9 = Has statistical significance been tested?
10 = Does the study report confidence intervals?
11 = Are there any confounding factors that have not been taken into account?
12 = Are the results applicable in practice/ community?

**Table 3. Summary of cross-sectional studies on the effect of noise exposure on occupational stress incidence**

| Author (Year) | Country | Sample | P | I | C | O |
|---|---|---|---|---|---|---|
| Handayani. (2016) | Indonesia | 50 | Oil palm factory employees | Exposed to noise ≥ 85dB | Not exposed to noise (<85 db) | Work stress |
| Mursali et al. (2009) | Indonesia | 326 | Yarn spinning worker | Exposed to noise ≥ 85dB | Not exposed to noise (<85 db) | Job stress |
| Ningsih and Fitri. (2017) | Indonesia | 65 | Welding workshop workers | Exposed to noise ≥ 85dB | Not exposed to noise (<85 db) | Work stress |
| Nuaim et al. (2015) | Malaysia | 80 | Manufacture workers | Exposed to noise ≥ 85dB | Not exposed to noise (<85 db) | Work stress |
| Yanti et al. (2013) | Indonesia | 65s | Welding workshop workers | Exposed to noise ≥ 85dB | Not exposed to noise (<85 db) | Work stress |

**Table 4. Adjusted Odd Ratio, Convidence Interval and Significancies of noise exposure on occupational stress incidence**

| Author (year) | aOR | 95%CI | p |
|---|---|---|---|
| Handasyani. (2016) | 24.38 | 0.80 to 739.84 | 0.001 |
| Mursali et al. (2009 | 2.46 | 1.33 to 4.55 | 0,000 |
| Ningsih and Fitri (2017) | 2.05 | 1.17 to 3.58 | 0.004 |
| Nuaim et al. (2015) | 10.1 | 0.89 to 10.31 | <0,05 |
| Yanti et al. (2013) | 8.12 | 1.63 to 40.43 | 0.004 |

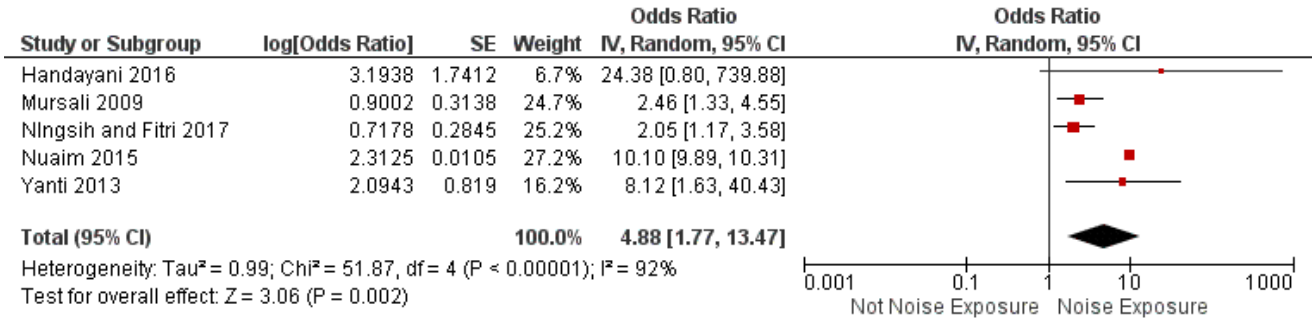


**Figure 3. Forest plot the effect of noise exposure on work stress**

Figure 3 showed that workers who were exposed to noise had a 4.88 times higher chance of experiencing work stress than those who were not (aOR=4.88; 95% CI= 1.77 to 13.47; p=0.002). The research data's I2 value of 92% indicates that the distribution of the data is heterogeneous (random effect model).

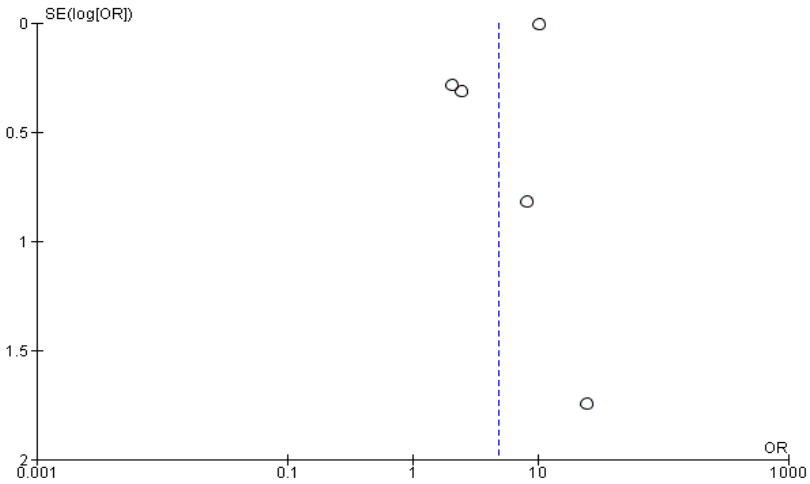


**Figure 4. Funnel Plot the effect of noise exposure on work stress**

The asymmetric distribution between the right and left plots in Figure 4's funnel plot shows publishing bias. Two plots are on the left and three plots are on the right. The standard error (SE) of the plot to the right of the chart looks to be between 0 and 2. The standard error (SE) of the plot to the left of the graph looks to be between 0 and 0.50.

**Table 5. Summary of cross-sectional studies on the effect of noise exposure on hypertension incidence**

| Author (Year) | Country | Sample | P | I | C | O |
|---|---|---|---|---|---|---|
| Shrestha and Shiqi. (2017) | China | 274 | Steel factory worker | Exposed to noise ≥ 85db | Not exposed to noise (<85db) | Hyper-Tension |
| Nserat et al. (2017) | Jordan | 191 | Industrial plant worker | Exposed to noise ≥ 85db | Not exposed to noise (<85db) | Hyper-Tension |
| Khairani and Achmadi. (2020) | Indonesia | 51 | Gold mining worker | Exposed to noise ≥ 85db | Not exposed to noise (<85db) | Hyper-Tension |
| Utami et al. (2020) | Indonesia | 120 | Welding and mechanical workers | Exposed to noise ≥ 85db | Not exposed to noise (<85db) | Hyper-Tension |
| Zhou et al. (2019) | China | 1,213 | Steel factory workers | Exposed to noise ≥ 85db | Not exposed to noise (<85db) | Hyper-Tension |
| Attarchi et al. (2012) | Iran | 331 | Tire industry workers | Exposed to noise ≥ 85db | Not exposed to noise (<85db) | Hyper-Tension |

| | | | | | | |
|---|---|---|---|---|---|---|
| Wu et al. 2022) | China | 500 cases and 4,356 controls | Automobile industry workers | Exposed to noise ≥ 85db | Not exposed to noise (<85db) | Hyper-Tension |
| Kim and Ahn. (2021) | South Korea | 107,407 cases and 107,407 controls | Male workers in South Korea who exposed to noise | Exposed to noise ≥ 85db | Not exposed to noise (<85db) | Hyper-Tension |
| Wang et al. (2018) | China | 286 cases and 630 controls | Coal and Electricity Company workers | Exposed to noise ≥ 85db | Not exposed to noise (<85db) | Hyper-Tension |

**Table 6. Adjusted Odd Ratio, Convidence Interval and Significancies of noise exposure on hypertension incidence**

| Author (year) | aOR | 95%CI | p |
|---|---|---|---|
| Shrestha and Shiqi. (2017) | 1.84 | 1.35 to 2.51 | 0.01 |
| Nserat et al. (2017) | 4.7 | 1.6 to 13.8 | 0.001 |
| Khairani and Achmadi. (2020) | 4.86 | 1.32 to 17.90 | 0.029 |
| Utami et al. (2020) | 9.53 | 1.67 to 53.84 | 0.003 |
| Zhou et al. (2019) | 2.03 | 1.15 - 3.58 | 0.034 |
| Attarchi et al. (2012) | 4.81 | 1.41 to 13.25 | 0.001 |
| Wu et al. (2022) | 4.92 | 2.92 to 8.28 | 0.002 |
| Kim and Ahn. (2021) | 1.42 | 1.38 to 1.45 | 0.00 |
| Wang et al. (2018) | 1.52 | 1.11 to 2.08 | 0.014 |

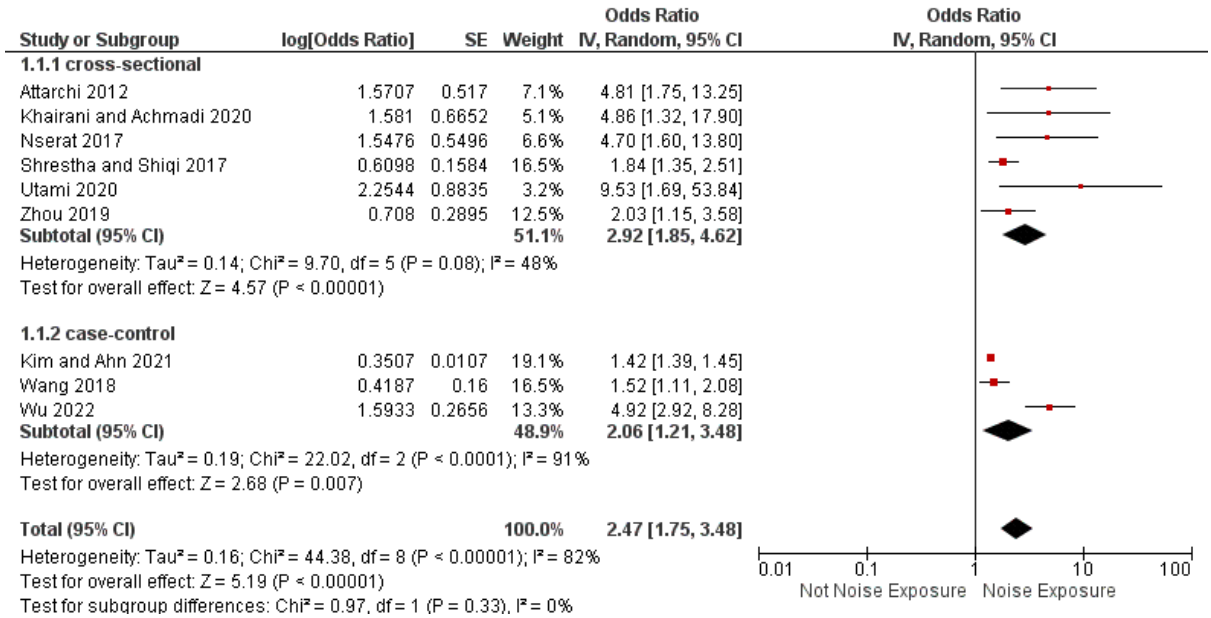


**Figure 5. Forest plot the effect of noise exposure on hypertension**

Figure 5's forest plot illustrates that noise exposure at work raises the risk of hypertension by 2.47 times relative to no exposure, and that this increase is statistically significant (aOR= 2.47; 95% CI= 1.75 to 3.48; p0.001). The research data's I2=82% heterogeneity indicates that the data distribution is heterogeneous (random effect

model). A cross-sectional study design showed statistical results with subgroup analysis (aOR= 2.92; 95% CI=1.85 to 4.62; p= 0.000). The results for the case control study design are statistically significant (aOR = 2.06; 95% CI =1.21 to 3.48; p = 0.007). The outcomes had statistical significance.

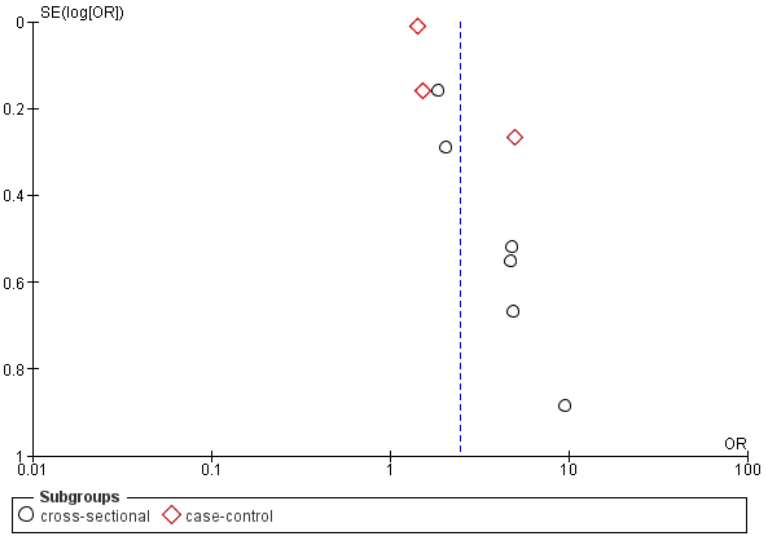


**Figure 6. Funnel plot the effect of noise exposure on hypertension**

The asymmetric distribution between the right and left plots in Figure 5's funnel plot indicates publishing bias. 4 plots are on the left and 5 plots are on the right. The standard error (SE) of the plot to the right of the graph looks to be between 0.2 and 1. The standard error (SE) for the plot to the left of the graph appears to be between 0 and 0.40.

## DISCUSSION

This study raises the issue of the impact of noise exposure on work stress and hypertension through systematic research and meta-analysis. This systematic review and meta-analysis used multivariate analysis, controlled research for confounding variables that can be seen from the study inclusion criteria, and statistical findings presented as adjusted odds ratio (aOR). Using RevMan 5.3 and the general inverse variance approach, the combined estimate of the effect of noise exposure on job stress and hypertension was analyzed.

Forest plots and funnel plots are used to illustrate the findings of the systematic study and meta-analysis. A summary of each study included in the meta-analysis is given in the forest plot, along with an estimate of the final result (Murti, 2016). The heterogeneity (amount of variance) is visually represented by the funnel plot (Murti, 2018). Funnel plots, which may be calculated in a variety of methods, depict the link between study effect sizes and sample sizes of the numerous studies under consideration.

The primary studies that met the criteria regarding the effect of noise exposure on work stress and hypertension were 14 articles all from Asia (Indonesia, Malaysia, China, Jordan, Iran and South Korea). 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 work stress and occupational diseases, one of which is hyper-

tension which is a silent killer. This noise can increase blood pressure and also psychologically increase work stress that occurs to industrial workers.

Noise is heard as a stimulus to the auditory nerve cells in the ears caused by vibrations from noise sources (production machines). Wave it propagates through the air or other conductors, activating the nervous system sympathetic and hormonal centers in the brain (hypothalamus) such as catecholamines, epinephrine, norepinephrine, glucocorticoids, cortisol (stress hormone), and cortisone (Hahad et al., 2019). The Hypothalamus Pituitary Adrenal (HPA) is an important part of the neuroendocrine system related to the occurrence of stress, adrenal hormones derived from the adrenal medulla while corticosteroids are produced by the adrenal cortex (Eze et al., 2020). Excess of the hormone cortisol can impair function in the prefrontal cortex, namely: emotional center. This area also functions to regulate planning, reasoning functions, and control of stimuli or impulses. The hypothalamus stimulates the pituitary Then the pituitary will stimulate the sympathetic nerves (Kim et al., 2018).

At times of stress (stressor) has been identified, the brain will send messages that are biochemistry to all systems in the body. As a result, breathing will increase,bblood pressure rises, muscles become tense, and other physiological symptoms arise. Individuals have only limited sources of energy and limitations in the ability to deal with stressors so the individual becomes stressed (Nuzulia, 2010).

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 (Fujino et al., 2001; Wang et al., 2018)Hypertension incidence and noise level are significantly correlated. Workers must use personal protection equipment (PPE) such as earplugs and/ or earmuffs near loud sources to reduce danger. Additionally, firm management must routinely maintain heavy machinery, equipment, and other pieces of equipment to avoid exposure to sound levels that are too high (Putra et al., 2020).

**a.Effect of noise exposure on the incidence of work stress**

Five cross-sectional observational research articles were used in the meta-analysis to examine how noise exposure affects the frequency of work stress. The findings of this study are statistically significant to noise (aOR=4.88; 95% CI=1.77 to 13.47; p= 0.002) and demonstrate that workers who are exposed to noise have a chance of feeling job stress up to 4.88 times greater than individuals who are not exposed to noise. The research data's heterogeneity indicates I2=92%, indicating that the data's distribution is heterogeneous (random effect model).

Noise exposure increases the incidence of work stress in the workplace, these results are in accordance with the hypothesis. based on research (Tak et al., 2009; Handayani, 2016) from 50 people, employees who are not noisy with no stress are 11 people (91.7%). And one person who is stressed (8.3%) while the noisy employee with 22 people were not stressed (57.9%) and 16 people are stressed (42.1%). From these results it was found that noise increased work stress by 24.36 times compared to employees who were not exposed

to noise. In this study, it was also found that heavy workloads had an effect on increasing work stress.

Work stress and noise levels are significantly correlated (OR=2.46; 95% CI 1.33-4.55). Workers who work in noisy environments who do not always or never wear earplugs are more likely to experience stress than those who work in quiet environments and do not (OR=21.76; 95% CI 8.09-58.52). This study shows that noise has negative health impacts due to stress since it frequently causes stress in a number of different ways (Mursali et al., 2009). The findings of this study (Liu et al., 2020; De Souza et al., 2015) show that the occurrence of work stress was linked with all relevant work stressor factors. Workers who have risk factors for role ambiguity, role conflict, qualitatively excessive workload, quantitatively excessive workload, and career development will be more likely to feel stress than workers who do not have the aforementioned risk factors. Shift work and the occurrence of work stress are significantly correlated. This is consistent with Japan research that demonstrates how shift work is a significant source of stress for factory workers.

Noise can also have an effect in the form of physiological disturbances in the form of increased blood pressure, increased pulse, vertigo and nausea. When continuously being in the middle of the noise on the spot work can result in loss of sensitivity hearing which leads to deafness and can also interfere with communication and one's concentration, this condition will increase stress levels. Noise intensity can often cause decrease in work performance, as one of the causes of stress and other health problems. Psychological impact of excessive noise is to reduce the tolerance of the workforce to other stressors, and reduce work motivation. Stress caused because noise exposure can lead to early fatigue, anxiety and depression (Recio et al., 2016; T. Chang et al., 2013).

In contrast to tranquil sound, impulsive sound increased physiological and psychological stress and impaired performance. The elevated sound level, which was obvious as a physiological stress reaction, contributed to some of this load (Radun et al., 2022). The results study from (Langer et al., 2020) suggest that office noise is associated with greater negative wellbeing. In another study it was stated that different forms of occupational noise levels even for lower decibels can create stress and reduce productivity in different work situations (Pretzsch et al., 2021).

High noise levels at work have been shown to alter brain activity linked to stress, according to a Malaysian study. The findings demonstrate that individuals who work in high-noise environments are more vulnerable to stress, as shown by lower HbO concentrations and EEG alpha as compared to individuals who work in low-noise environments (Alyan et al., 2021).

**b.Effect of noise exposure on the incidence of hypertension**

The meta-analysis looking into the effect of noise exposure on the incidence of hypertension used a total of 9 cross-sectional and case-control observational research publications as sources. This study shows that noise exposure at work raises the risk of hypertension by 2.47 times compared to those who are not exposed to noise, and that this increase is statistically significant (aOR= 2.47; 95% CI= 1.75 to 3.48; p=0.001). The research data's I2=82% heterogeneity indicates that the data distribution is heterogeneous (random effect model). The research data's heterogeneity showed I2=92%, meaning that the data's distribution is heterogeneous (random effect model). A cross-sectional study

design showed statistical results with subgroup analysis (aOR=2.92; 95% CI=1.85 to 4.62; p=0.000). The results for the case control study design are statistically significant (aOR = 2.06; 95% CI =1.21 to 3.48; p=0.007). The outcomes were statistically significant.

There is a correlation and dose response relationship between occupational noise exposure and elevated systolic and diastolic blood pressure and risk of prevalence, according to research done in Hangzhou, China, on the relationship between systolic and diastolic blood pressure in relation to case group of 1390 workers exposed to occupational noise and 1399 workers in the control group who were not exposed (Chen et al., 2017). Other study (Zhou et al., 2019) the odds ratio of hypertension in workers exposed to industrial noise was discovered when hypertension was defined as SBP/DBP, 130/80mm Hg or more. Workers who were exposed to noise exhibited a higher prevalence of hypertension than the control group, in line with the original criteria of the condition (adjusted OR: 1.88, 95% CI: 1.45–2.44).

According to the findings of the Zhang study (Zhang et al.,2024), workplace noise exposure may raise a group's chance of developing hypertension. However, the findings of several cross-sectional research suggested that there was no correlation between noise exposure and changes in workers' blood pressure and heart rates (Utami et al., 2020). It is still unclear exactly how a biological process results in an increase in blood pressure. According to the general stress hypothesis, noise affects the endocrine and autonomic nerve systems, which in turn affects the homeostasis of the human body. The long-term development of chronic conditions like atherosclerosis, hypertensionand these long-lasting changes in endogenous risk variables brought on by noise induced dysregulation and impaired metabolic function enhance ischemic heart disease (Mursali et al., 2009; Kim and Ahn, 2021).

Stress and the metabolic changes it caused may be a mediating factor in the association between exposure to loud noise and the risk of high blood pressure. Numerous hormones and chemicals, including cortisol, adrenaline, and noradrenaline, are secreted in reaction to stress. It has been demonstrated that as the concentration of these substances rises, peripheral vasoconstriction and arterial blood pressure also rise (Nserat et al., 2017; De Souza et al.,2015). The risk of hypertension in these settings may potentially be increased by additional employment circumstances (Nserat et al., 2017; Nuzulia, 2010; T.Y. Chang et al., 2013). Engineering solutions that restrict noise generation at its source can reduce the majority of occupational noise exposure. Noise assessments, noise controls, audiometric monitoring of workers' hearing, appropriate use of hearing protection, worker education, and recording programs to assess changes in threshold levels are all urgently required in order to effectively reduce the global burden of occupational noise-induced hearing (Zhou et al., 2019).

This study has a number of advantages. First, a systematic review and meta-analysis were carried out using the PRISMA approach. Second, a comprehensive search method was used to compile all related articles. Thirdly, the review procedure outlined in this work was carried out by impartial reviewers. This study's limitations include search bias due to the use of only four databases and language bias due to the use of only English and Bahasa articles.

## AUTHOR CONTRIBUTION

Maria Paskanita Widjanarti is the main researcher who select the topic, explores and collects data. Sumardiyono and Aurina Firda Kusuma Wardani played a role in analyzing data and reviewing research documents.


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## CONFLICT OF INTEREST

The authors declare that they have no competing interests.

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