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Masters Program in Public Health, Universitas Sebelas Maret

Meta-Analysis

Meta-Analysis the Effect of Excessively Loud Sounds on Noise Induced Hearing Loss in Manufacturing Industry Workers

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ABSTRACT

Background: Noise that exceeds the threshold value can cause work-related illness, which can be in the form of hearing loss or damage to the ear either temporarily or permanently after being exposed for a certain period of time without adequate protection. Noise induced hearing loss (NIHL) is a working condition that often occurs in various industrial spectrums. This study aims to estimate the magnitude of the effect of noise on NIHL in manufacturing industry workers.
Subjects and Method: This research is a systematic review and meta-analysis. Article search was carried out based on the PICO Model eligibility criteria including: P= Manufacturing industry worker; I= Noise intensity ≥85 dB; C= Noise intensity <85 dB; O= NIHL. The articles used come from 3 databases, namely: PubMed, Google Scholar, and Science Direct. The keywords used include "hearing loss" AND "noise induced hearing loss" AND "manufacturing industry" AND "cross-sectional study". The inclusion criteria in this study included full text articles with a cross-sectional study design, the adjusted odds ratio (aOR) was used, the articles were published in the 2003-2022 range, and the outcome was NIHL. Articles were analyzed using the PRISMA diagram and the Review Manager 5.3 application.
Results: A meta-analysis of 10 articles from Arab Saudi, Ethiopia, Kuwait, Tanzania, Thailand, Cina, Yordania, Norwegia, and Iran showed that ≥85 dB noise increases the likelihood of NIHL in industrial manufacturing workers. Manufacturing workers exposed to noise intensity of ≥85 dB increased NIHL by 1.90 times compared to manufacturing workers exposed to <85 dB of noise, and this result was statistically significant (aOR= 1.90; CI 95%= 1.61 to 2.26; p< 0.001).
Conclusion: A meta-analysis of 10 cross-sectional studies concluded that noise increases the incidence of NIHL in manufacturing industry workers.

Keywords: noise intensity, NIHL, manufacturing industry workers

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BACKGROUND

Labor has an important role in development. Labor is an element that directly deals with various consequences of technological progress. In development, workers should be given protection, health care and development of welfare or social security as well as protection against occupational diseases.

Noise that exceeds the threshold value can cause work-related illnesses, which can be in the form of hearing loss or damage to the ear either temporarily or permanently

after being exposed for a certain period of time without adequate protection (Wulandari, 2010). Based on OSHA (Occupational Health and Safety Administration) every year, about 30 million people in the United States who work are exposed to hazardous noise. and more or less half (75-140 million) are in Southeast Asia which has a fairly high prevalence of deafness, namely 4.6%, including Indonesia (Putri et al., 2020).

Noise induced hearing loss (NIHL) is a working condition that often occurs in various industrial spectrums. Occupational hearing loss can be prevented through a hierarchy of controls, which prioritizes the use of engineering controls over administrative controls and personal protective equipment (Mirza et al., 2018).

Study by Prasetyowati et al. (2019) showed that the prevalence of NIHL increased every year, starting from 19.1% in 2014 then increasing to 23.5% in 2015 and then in 2016 it almost doubled to 57.4%.

Based on the background above and several similar previous research findings regarding noise in the work area causing hearing loss. So, the researcher is interested in conducting a study using a systematic review and meta-analysis which can summarize some of the results of primary studies or previous studies with a systematic search to combine the results and get more precise estimates to draw new conclusions. This study aimed to estimate the effect of noise on NIHL in manufacturing industry workers.

SUBJECTS AND METHOD

1. Study Design

This research is a systematic review and meta-analysis using the PRISMA diagram. Article search was carried out based on the eligibility criteria of the PICO Model. P= Manufacturing industry workers; I= Noise intensity ≥85 dB; C= Noise intensity <85 dB; O= NIHL The articles used come from 3 databases, namely: PubMed, Google Scholar, and ScienceDirect. With keywords including "hearing loss" AND "noise induced hearing loss" AND "manufacturing industry" AND "cross section study".

2. Steps of Meta-Analysis

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

1) Formulate PICO format research questions (Population, Intervention, Comparison, and Outcome).
2) Look for primary study articles from various electronic and non-electronic databases such as PubMed, Science Direct, Google Scholar, and Scopus.
3) Perform screening to determine inclusion and exclusion criteria and carry out a critical assessment.
4) Extract data from primary studies and synthesize effect estimates using the revman application.
5) Interpret the results and draw conclusions.

3. Inclusion Criteria

The inclusion criteria include full paper article with a cross-sectional study, the research subjects were manufacturing industry workers, the relationship measure used was the adjusted odds ratio (aOR), the research outcome was NIHL.

4. Exclusion Criteria

Statistical results are reported in the form of bivariate analysis, articles published in languages other than English.

5. Operational Definition of Variables

Noise intensity: is the amount of pressure (energy) emitted by a sound. Sound intensity in the workplace not only causes hearing loss such as a decrease in the value of the worker's hearing threshold, but can also cause hearing loss which does not directly affect workers, which can cause stress, communication disorders and cause worker productivity to decrease (Rakhmawati et al., 2018).

Noise Induced Hearing Loss: Sensorineural type hearing loss caused by exposure to loud noise for a long time, usually due to noise in the work environment (Lulang et al., n.d.)

Manufacturing Industry Workers: The manufacturing industry is an industrial sector that plays an important role in the economy. The manufacturing industry operates to provide people's needs, such as food, clothing, and other needs.

6. Study Instruments

Quality assessment in this study used a critical assessment checklist from the Cross Sectional Study Checklist published by CEBM.

7. Data Analysis

The articles in this study were collected according to the PRISMA flowchart and analyzed using the Review Manager 5.3 application. The analysis was carried out by calculating the effect size and heterogeneity consistency value (I^2) of the selected research results.

RESULTS

Research for articles in this study through databases that include PubMed, Google Scholar, and Science Direct. With keywords such as: "hearing loss" OR "noise exposure" OR "noise induced hearing loss" AND "industry". The process of reviewing related articles can be seen in the PRISMA flow diagram in Figure 1. Research related to the effect of noise on noise induced hearing loss in the manufacturing industry consisted of 10 articles from the initial search process yielding 1,706 results. After the deletion process of published articles obtained 130 articles with 80 of which met the requirements for further full text review as many as 10 articles that met the quality assessment were included in the quantitative synthesis using meta-analysis.

It can be seen in Figure 2 that the research articles came from 2 from the African continent (Ethiopia, Tanzania) and 8 from the Asian continent (Malaysia, Kuwait, Thailand, China, Jordan, Saudi Arabia and Taiwan).

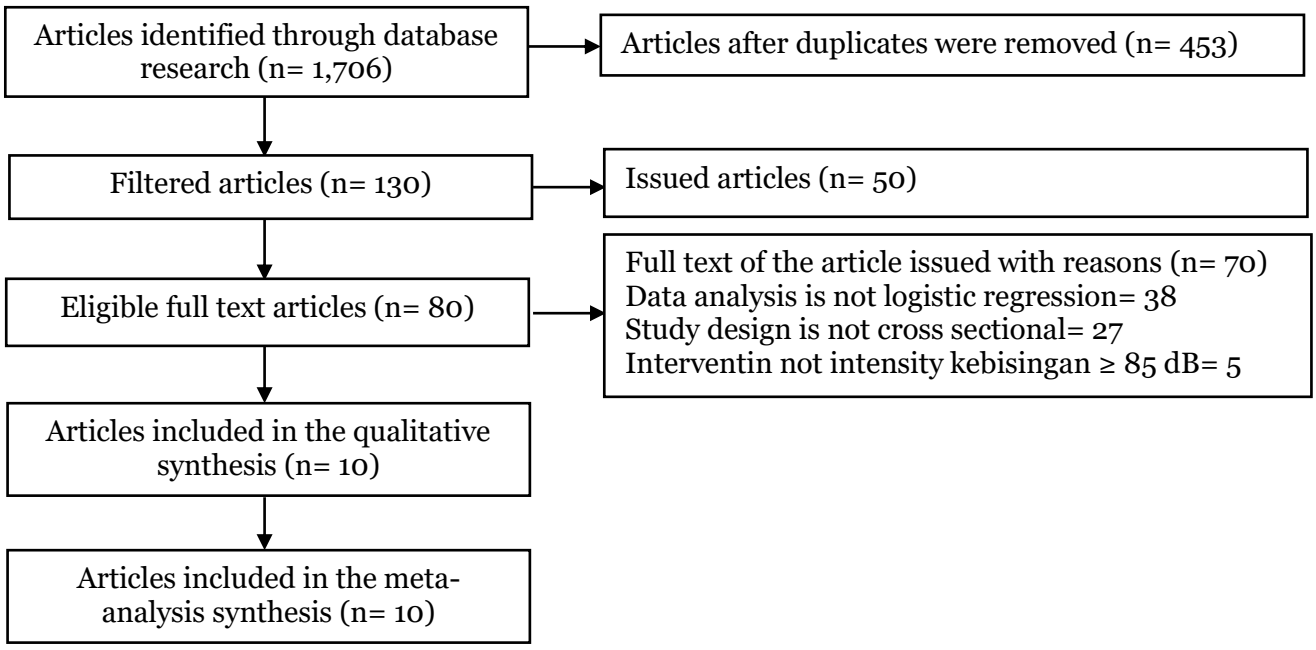

Figure 1. PRISMA Flow Diagram of research on the influence of noise on noise induced hearing loss

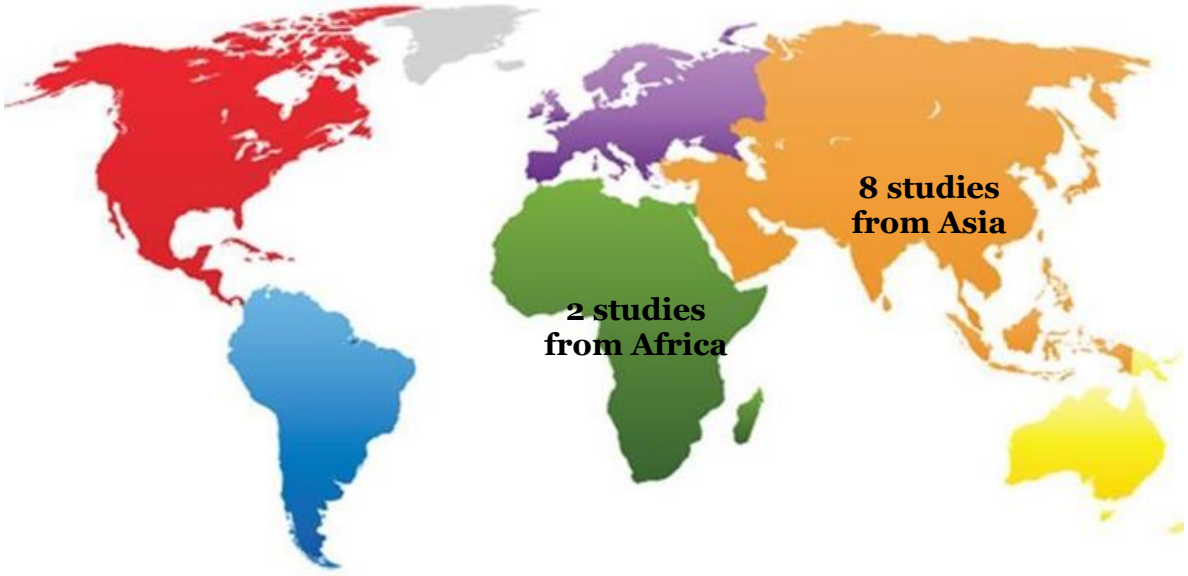

Figure 2. Map of the research area on the effect of noise on the occurrence of noise induced hearing loss

Table 1. Results of quality assessment of case-control studies on the effect of noise exposure on noise induced hearing loss

Primary Study	Criteria of Questions												Total
	1	2	3	4	5	6	7	8	9	10	11	12	
Melese et al. (2022)	2	2	2	2	2	2	2	2	2	2	2	2	24
Ammar et al. (2022)	2	2	2	2	2	2	2	2	2	2	2	2	24
Buqammaz et al. (2021)	2	2	2	2	2	2	2	2	2	2	2	2	24
Makame et al. (2020)	2	2	2	2	2	2	2	2	2	2	1	2	23
Sakunkoo et al. (2019)	2	2	2	2	2	2	2	2	2	2	2	2	24
Li et al. (2019)	2	2	2	2	2	2	2	2	2	2	2	2	24
Almaayeh et al. (2018)	2	2	2	2	2	2	2	2	2	2	2	2	24
Ahmed (2012)	2	2	2	2	2	2	2	2	2	2	2	2	24
Liu et al. (2010)	2	2	2	2	2	2	2	2	2	2	1	2	23
Chang et al. (2003)	2	2	2	2	2	2	2	2	2	2	2	2	24

Description of the question criteria:

1 = Does this objective clearly address the research focus/problem?
2 = Is the cross-sectional research method suitable for answering the research questions?
3 = Is the method of selecting research subjects written clearly?
4 = Does the sampling method not cause bias (selection)?
5 = Does the research sample taken represent the designated population?
6 = Was the sample size based on pre-study considerations?
7 = Was a satisfactory response achieved?
8 = Is the research instrument for examining noise induced hearing loss valid and reliable?
9 = Was statistical significance assessed?
10 = Are confidence intervals given for the main outcome?
11 = Have confounding factors (gender and age) been taken into account?

12 = Are the results applicable to your research?

Description of the answer score:

0 = No
1 = Hesitant
2 = Yes

After assessing the quality of the studies, a number of 10 articles were obtained with a cross-sectional study design which will be used as a source for a meta-analysis of the effect of noise on noise induced hearing loss (NIHL) in manufacturing industry workers. The article is then extracted and summarized according to the research PICO.

Table 2. Description of the primary studies of noise exposure included in the meta-analysis (N=5,910)

Author (year)	Country	Sample size	P	I	C	O
Melese et al. (2022)	Ethiopia	300	Metal industry workers	Experiencing noise	No noise	Noise induced hearing loss
Ammar et al. (2022)	Malaysia	420	Palm factory workers	Experiencing noise	No noise	Noise induced hearing loss
Buqammaz et al. (2021)	Kuwait	710	SIMC industrial workers	Experiencing noise	No noise	Noise induced hearing loss
Makame et al. (2020)	Tanzania	119	Gold mine workers	Experiencing noise	No noise	Noise induced hearing loss
Sakunkoo and Kittikong (2019)	Thailand	207	Pulp and paper plant's factory workers	Experiencing noise	No noise	Noise induced hearing loss
Li et al. (2019)	Cina	1,041	Factory workers in Nanjing	Experiencing noise	No noise	Noise induced hearing loss
Almaayeh et al. (2018)	Yordania	140	Industrial workers in Jordan	Experiencing noise	No noise	Noise induced hearing loss
Ahmed (2012)	Arab Saudi	468	Steel industry workers in Saudi Arabia	Experiencing noise	No noise	Noise induced hearing loss
Liu et al. (2010)	Cina	2,400	Industrial workers in China	Experiencing noise	No noise	Noise induced hearing loss
Chang et al. (2003)	Taiwan	105	Viscose rayon factory workers	Experiencing noise	No noise	Noise induced hearing loss

Based on Table 2, the description of primary research on the effect of noise on noise induced hearing loss was conducted through a meta-analysis of 10 articles with various research locations, namely from Ethiopia, Malaysia, Kuwait, Tanzania, Thailand, China, Jordan, Saudi Arabia, and Taiwan. Similarities were found in the study, namely the cross-sectional study design, the research subjects were manufacturing industry workers, the intervention was given a noise intensity of ≥85 dB with a noise intensity of <85 dB. In this study there were also differrences in the number of samples, with the smallest being 105 and the highest being 2,400.

Table 3. Effect estimates (Odds Ratio) of all primary studies performed in the meta-analysis (N=5,910)

Author (Year)	OR	95%CI	
		Lower Limit	Upper Limit
Melese et al. (2022)	2.20	1.10	6.50
Ammar et al. (2022)	3.46	1.78	6.71
Buqammaz et al. (2021)	2.00	1.70	2.40
Makame et al. (2020)	1.70	1.69	1.97
Sakunkoo et al. (2019)	4.12	1.59	10.71
Li et al. (2019)	1.28	1.03	1.60
Almaayeh et al. (2018)	4.20	1.60	10.50
Ahmed (2012)	2.40	1.30	4.30
Liu et al. (2010)	2.38	1.27	4.46
Chang et al. (2003)	1.40	0.70	2.50

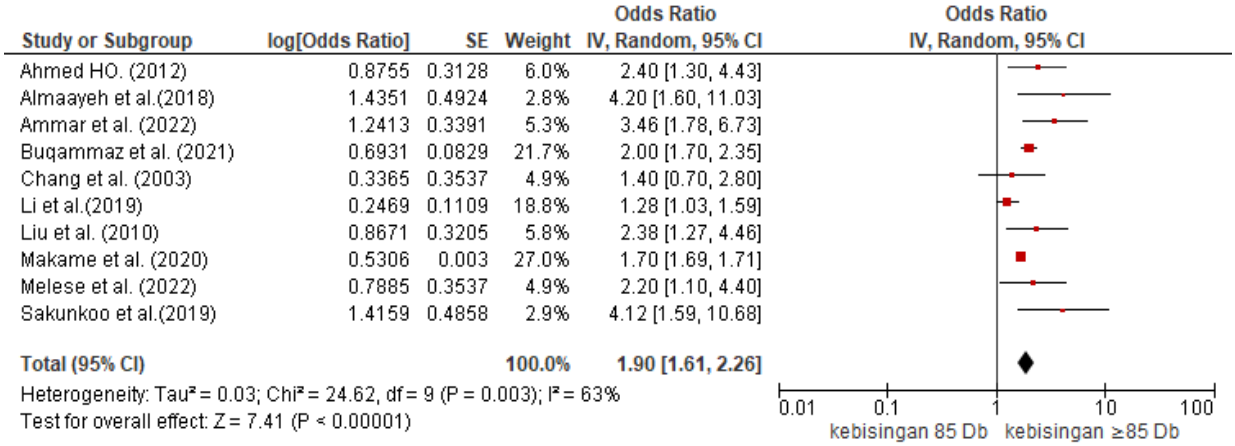

Figure 3. Forest plot of the effect of noise exposure on the occurrence of noise induced hearing loss

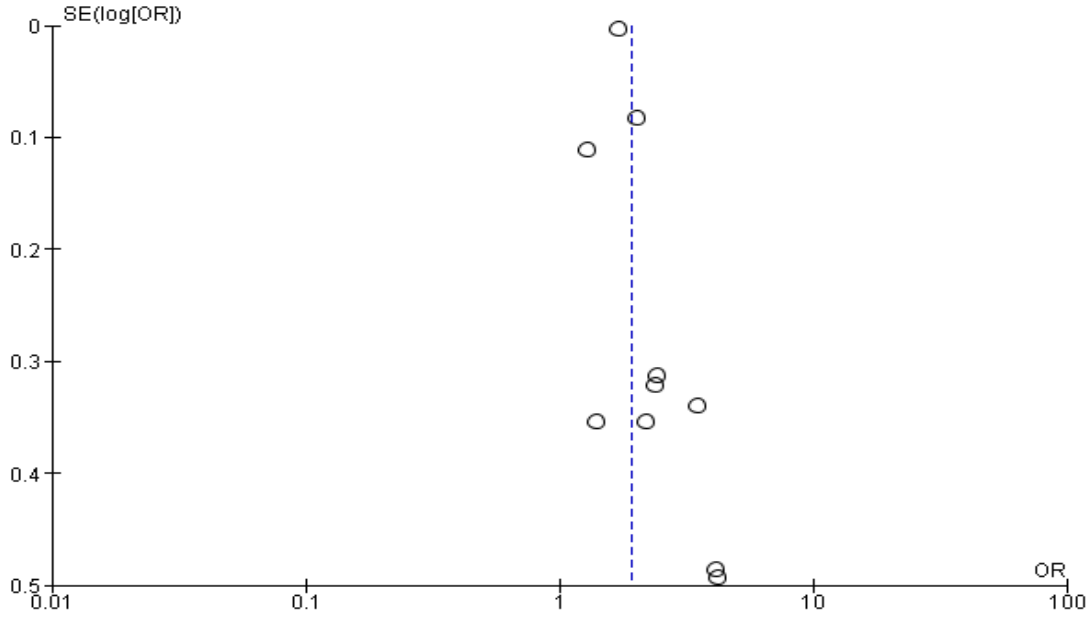

Figure 4. Funnel plot of the effect of noise exposure on the occurrence of noise induced hearing loss

Forest plot Figure 3. shows that noise ≥85 dB increases the possibility of noise induced hearing loss in manufacturing industry workers. Manufacturing industry workers exposed to noise intensities ≥85 dB increased noise induced hearing loss by 1.90 times compared to manufacturing industry workers exposed to noise <85 dB (aOR= 1.90; 95% CI= 1.61 to 2.26; p<0.001), and the results were significant statistically.

The funnel plot in Figure 4 shows the unequal distribution of effect estimates between studies to the right and left of the estimated mean vertical line. The picture above shows that there is publication bias (overestimate). The left plot consists of 3 plots with a standard error between 0 and 0.2, the right plot contains 6 plots with a standard error between 0 and 0.5, and 1 plot is on a vertical line.

DISCUSSION

Noise Induced Hearing Loss (NIHL) continues to be one of the most common occupational conditions and occurs across a wide spectrum of industries.

A total of 10 case-control observational research articles originating from Europe, the African continent, the Asian continent showed that the results of workers who were exposed to noise had a risk of experiencing noise induced hearing loss (NIHL) by 1.90 times compared to workers who were not exposed to noise. The results are statistically significant (aOR= 1.90; 95% CI= 1.61 to 2.26; p< 0.001). The heterogeneity of the research data shows I^2 = 63% so that the distribution of the data is stated to be heterogeneous (random effect model).

Occupational noise exposure and hearing loss have an adverse effect on work safety and can increase the likelihood of work-related injuries. This means reducing exposure to noise in the workplace can contribute to improving safety in workplaces where noise is a factor. In addition, using hearing aids can reduce the risk of work injuries among workers with hearing loss (Amjad-Sardrudi et al., 2012).

Personal noise exposure levels for maintenance workers at gold mine sites in Tanzania are above the occupational exposure limits set by WHO, NIOSH and OSHA Tanzania. Common hearing problems faced by workers in heavy equipment maintenance shops include hearing loss, ringing in the ears, speech disorders and ear infections. The use of organic solvents, duration of exposure and prolonged twelve-hour work shifts can affect the level of noise exposure and the hearing status of workers. In addition to being given the HPD and mine safety regulations (policy on the use of a mandatory HPD), there are workers who do not use the HPD as needed. Therefore the issue of satisfaction with HPD may be important for use adherence (Makame et al., 2020).

The results of other studies show that both industrial factories have a high risk of experiencing noise-induced hearing loss due to excessive noise exposure in the workplace. High levels of noise exposure, coupled with a reluctance to use suitable hearing protection devices put most employees at high risk of hearing loss (Ahmed et al., 2001). Use of ear protection devices to prevent noise disturbance to workers. Workers exposed to high noise levels, namely 42.6% who use ear protection, 60% who do not use ear protection. There is a strong relationship between age and noise disturbance (Salminen et al., 2016).

Researchers have identified that noise in the work environment increases the rate of hearing loss, which contribute to a person's risk of noise induced hearing loss.

AUTHOR CONTRIBUTION

Rizki Aqsyari D as a researcher who selects topics, searches for and collects research

data. Sumardiono and Bhisma Murti analyzed the data and reviewed research documents.

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CONFLICT OF INTEREST

There is no conflict of interest in this study.

REFERENCES

Ahmed HO, Dennis JH, Badran O, Ismail M, Ballal SG, Ashoor A, Jerwood D (2001). Occupational noise exposure and hearing loss of workers in two plants in eastern Saudi Arabia. Ann Occup Hy. 45(5): 371–380. doi: 10.-1016/S0003-4878(00)00051-X.

Almaayeh M, Al-Musa A, Khader YS (2018). Prevalence of noise induced hearing loss among Jordanian industrial workers and its associated factors. Int J Occup Environ Med. 61(2): 267–271. doi: 10.3233/WOR-182797.

Amjad-Sardrudi H, Dormohammadi A, Golmohammadi R, Poorolajal J (2012). Effect of noise exposure on occupational injuries: A cross-sectional study. Res J Health Sci. 12(2): 101–104.

Ammar S, Daud A, Ismail AF, Razali A (2022). Screening for noise-induced hearing loss among palm oil mill workers in Peninsular Malaysia: a comparison across noise exposure levels. Standards. 2(1): 32–42. doi: 10.3390/standards2010003.

Buqammaz M, Gasana J, Alahmad B, Shebl M, Albloushi D (2021). Occupational noise-induced hearing loss among mig-rant workers in Kuwait. Int J Environ Health Res. 18(10). doi: 10.3390/ij-erph18105295.

Chang SJ, Shih TS, Chou TC, Chen CJ, Chang HY, Sung FC (2003). Hearing loss in workers exposed to carbon disulfide and noise. Environ Health Perspect. 111(13): 1620 –1624. doi: 10.1289/ehp.6289.

Li X, Dong Q, Wang B, Song H, Wang S, Zhu B (2019). The influence of occupational noise exposure on cardiovascular and hearing conditions among industrial workers. Sci Rep. 9(1): 1–7. doi: 10.1038/s41598-019-47901-2.

Liu YM, Li XD, Guo X, Liu B, Lin AH, Ding YL, Rao SQ (2010). SOD2 V16A SNP in the mitochondrial targeting sequence is associated with noise induced hearing loss in Chinese workers. Dis Markers. 28(3): 137–147. doi: 10.323-3/DMA-2010-0693.

Makame KR, Sakwari G, Mamuya S (2020). Noise exposure levels and associated effects among workers in heavy machine maintenance workshops: a study in gold mining site. Int J Innov Res. 7(6).

Melese M, Adugna DG, Mulat B, Adera A (2022). Hearing loss and its associated factors among metal workshop workers at Gondar city, Northwest Ethiopia. Public Health Front. 10. doi: 10.33-89/fpubh.2022.919239.

Mirza R, Kirchner DB, Dobie RA, Crawford J, Dreger M (2018). Occupational noise-induced hearing loss. J Occup Environ Med. 60(9): E498–E501. doi: 10.1097/JOM.0000000000001423.

Wulandari DW (2010). Pengendalian potensi bahaya kebisingan di area product handling sebagai upaya pencegahan penyakit akibat kerja di PT Tri Polyta Indonesia, Tbk. Thesis. Study Program of Diploma III of Corporate

Hygiene and Safety and Occupational Safety and Occupational Health, Faculty of Medicine, Universitas Sebelas Maret.

Prasetyowati O, Wangge G, Purwitoadi N (2019). The effect of noise exposure on the incidence of noise-induced hearing loss and hypercholesterolemia in workers who manufacture heavy equipment. J Inform Frequency. 2(1): 37–46.

Putri R, Abdullah I, Dwi PS, Ihsani IP (2020). The relationship between noise and work period on the type of deafness and stress in PT. Tonas Cement. J Med. 5(1).

Rakhmawati A, Ramlan D, Yulianto Y (2018). The relationship between the sound intensity of production machines and exposure time with the hearing threshold of rice mill workers in Banjarsari village, Sumbang subdistrict, Banyumas district in 2017. Buletin Keslingmas. 37(3): 245–257. doi: 10.31983/keslingmas.v37i3.3872

Sakunkoo P, Kittikong P. (2019). Hearing capacity, noise level exposure and health effects in workers of pulp and paper plant, Khon Kaen Province. Environment Asia. 12(3): 151–158. doi: 10.14456/ea.2019.55.

Salminen S, Saari J, Saarela KL, Rasanen T, Scandinavian S, October N, Rasanen T (2016). Noise exposure, noise annoyance, use of hearing protection devices and distress among bluecollar workers. Scand Work Environ Health. 8–14.