Occupational Factors Associated with *Noise Induced Hearing Loss* among Welders in Bandar Lampung Indonesia

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Abstract. Noise Induced Hearing Loss (NIHL) is sensorineural hearing loss induced by prolonged high-intensity noise exposure. Industrial workers, such as welding workshop personnel, are at risk of getting occupational NIHL. The purpose of this study was to examine the association between occupational characteristics such as noise intensity, duration of noise exposure, duration of employment, and the usage of Hearing Protection Equipment (HPE) with NIHL. This study's design was analytical observational using a cross-sectional approach, and the sampling technique was total sampling. The total population was 67, with 59
samples. This study collected data using a sound level meter, audiometry test, and questionnaire (α= 10%). The prevalence of NIHL in welders was 23.70%, and the average noise exposure level ranged from 89.12 to 99.77 db. The duration of noise exposure ranges from 1 to 7 hours per day, whereas employment spans between 1 and 6 years. The Mann-Whitney test for the noise intensity variable yielded a p-value of 0.185. Fisher's exact test for the duration of exposure and duration of employment variables finds p-values of 0.579 and 0.007, respectively. There is a significant association between working period and NIHL. There is no significant association between noise exposure intensity and noise exposure duration with NIHL.

Keywords: Hearing Loss, NIHL, noise, welder, occupational disease.

INTRODUCTION

The rapid development of the industrial sector in the Indonesian economy covers all types of industries, including small industries. One of the sub-sectors of small industries is the metal raw material processing industry[1], [2]. One of the working processes of metal processing is welding or joining metals using gas [3]. Equipment used in the welding process has the potential to cause work accidents or Occupational Diseases (PAK) due to the pressure, heat, fire, and electricity generated [4], [5]. Basic Health Research Data (Riskesdas) in 2018 shows that the rate of workplace injuries in the working-age population was 5.4% to 21.1% [6].

Welding workshops, which are work areas for the welding process have potential hazards for their workers . Some types of potential hazards that can be identified in welding workshops such

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as ionizing and non-ionizing radiation such as ultraviolet and infrared rays, magnetic fields, heat, noise, small particle dust, metal fumes, gases, electricity, and musculoskeletal injuries [5]. Exposure to noise in the work environment can cause *Noise Induced Hearing Loss* (NIHL), which is a decrease in the sensorineural hearing threshold [7].

According to Riskesdas findings, the prevalence of hearing loss in Indonesia is 2.6%, with a prevalence of deafness of 0.09%. Meanwhile, the prevalence of hearing loss in Lampung Province exceeds the national average, ranked second only to East Nusa Tenggara Province [6]. A 2019 research of 70 welding workshop workers in Johan Pahlawan District, West Aceh Regency found that 57.1% of the workers had hearing loss [8]. Other investigations have found a hearing loss of ≤25 decibels (dB) of 68.3% to 81% in 120 welders from three automotive companies in Thailand [9].

Hearing loss, such as NIHL, has a wide-ranging influence on the lives of those who suffer from it, including difficulties in learning, feelings of loneliness, isolation, and frustration, particularly among the elderly. Hearing loss also has economic consequences, such as increased medical expenditures, educational expenses, decreased productivity, and social costs [10]. Hearing loss has been associated to decreased cognition, concentration, and memory, while in the working population NIHL had been found associated with the increase risk of occupational accident [11]. This study aims to determine the occupational factors associated to the prevalence of NIHL among welding workshop workers in Bandar Lampung City.

SUBJECT AND METHOD

This is an analytical observational study with a cross-sectional design. Data was collected using primary data and was conducted in the Kemiling and Sukarame districts of Bandar Lampung City from January 2020 to February 2021. This study was ethically reviewed and approved by the Health Research Ethics Commission, Faculty of Medicine, University of Lampung (No. 1744/UN26.18/PP.05.02.00/2020). The population in this study is all welding workshop workers in the Kemiling and Sukarame Districts of Bandar Lampung City in 2020, and the research sample consists of 59 respondents. The sample met the inclusion criteria and did not have any exclusion criteria. Total sampling was used as the sampling since the number of populations and the minimum sample size acquired using the formula are almost identical.

The operational definitions of the variables in this study are: 1) Noise exposure intensity, which refers to undesired noise emitted by production process equipment and/or labor tools at levels that can induce hearing loss. The measuring device used is a sound level meter, and the measurement results are expressed in decibels (dB) using a numerical measurement scale. 2) Duration of exposure, which is the average number of hours a worker is exposed to noise in a day. The instrument used for measurement is a questionnaire with an ordinal scale, and the results are described as ≤TLV and >TLV based on the Regulation of the Minister of Health of the Republic of Indonesia Number 70 of 2016 concerning Industrial Workplace Environmental Health. 3) The working period is the time from when the resepondent begins to work as a welder until the research is completed. The measurement tool is a questionnaire with an ordinal scale and outcomes

represented as ≤5 years and >5 years. 4) The use of ear protection equipment (EPE), which is the use of EPE in the form of ear plugs, earmuffs, or helmets while working, which is replaced once a month with proper and consistent use. The data were gathered through observation using an ordinal measurement scale, and measurement outcomes were described as Yes or No. 5) NIHL, which refers to pure tone audiometry revealed a notching of ≥25 dB at 3000 - 6000 Hz (NIHL). The measuring device utilized was an audiometry with an ordinal measurement scale. The measurement results were declared as not The measuring device utilized was an audiometry with an ordinal measurement scale, and the results were classified as non-NIHL or NIHL.

Data processing and analysis for this study were carried out utilizing data processing tools. The univariate analysis findings revealed the frequency distribution of responders based on NIHL incidents, noise exposure intensity, duration of noise exposure, working period, and use of EPE. Bivariate analysis findings were obtained using the Mann-Whitney and Fisher's Exact tests, which are alternatives to the T-test and Chi-Square.

RESULTS

This research was conducted in 7 welding workshops in Kemiling and Sukarame Districts, Bandar Lampung City which are named as workshops A, B, C, D, E, F, and G. The study respondents were dominated by workers with an age range of 20 – 30 years with a varying working period from 1 to 6 years. The education level of the most respondents is at the university and high school. There were only 2 respondents with a Junior High School. In addition, almost all respondents are permanent workers and only 1 person is a workshop owner. Most common symptoms of hearing loss experienced by respondents were tinnitus and ear pain, experienced by 17 and 9 people, respectively. The characteristics of the respondents of this study are presented in detail in Table 1.

The results of univariate analysis for NIHL variables showed that there were 45 respondents (76.30%) out of 59 respondents who did not experience NIHL and 14 respondents (23.70%) experienced NIHL. A total of 7 people from the number of respondents with NIHL had bilateral NIHL, while 4 people had NIHL in the right ear only and 3 people had NIHL in the left ear only.

Noise intensity

Noise intensity measurements are carried out for 6 working days during the working hour. The calculation of noise intensity was carried out by calculating the average intensity obtained for 6 days. The average value of the noise intensity of each workshop is 93.37 dB, 96.80 dB, and 93.33 dB, respectively, 99.77 dB, 89.12 dB, 94.48 dB, and 91.98 dB. The result shows that all respondents are working in an environment with a noise intensity of >85 dB. The complete results of these measurements are presented in Table 2.

Table 1. Respondent characteristics

Characteristic	Frequency (n)	Percentage (%)
Age		
20 – 30 years old	51	86,44
31 – 40 years old	8	13,56
Education Level		
Junior high school or equivalent	2	54,20
High school or equivalent	25	42,40
College	32	3,40
Working Period		
1 year	7	11,90
2 years	15	25,40
3 years	9	15,30
4 years	12	20,30
5 years	15	25,40
6 years	1	1,70
Employee status		
Owner	1	1,70
Permanent workers	58	98,30
Noise-related hobbies		
Yes	9	15,30
Not	50	84,70
Tinnitus		
Yes	17	28,80
Not	42	71,20
Ear pain		
Yes	9	15,25
Not	50	84,75
NIHL		
Yes	14	23,70
No	45	76,30

Duration of Exposure

The determination of the threshold limit value (TLV) of the duration of noise exposure is carried out by comparing the maximum permissible time based on the noise intensity of each workshop which is then adjusted to the Regulation of the Minister of Health of the Republic of Indonesia Number 70 of 2016 concerning the Health of the Industrial Work Environment. The results of univariate analysis for the exposure duration variable showed that there were 2 respondents (3.40%) out of 59 respondents who were exposed to noise during ≤TLV and 57 respondents (96.60%) were exposed to noise during >TLV. The complete duration of noise exposure in respondents is presented in Table 2.

Table 2. Noise Intensity and exposure duration

Workshop	Intensity (dB)	TLV	Duration	Number of workers exposed (n)
A	93,37	1 hour	5 hours	5
B	96,80	1 hour	4 hours	1
			6 hours	10
C	93,33	2 hours	4 hours	2
			6 hours	4
D	99,77	30 minute	7 hours	6
E	89,12	2 hours	2 hours	1
			7 hours	9
F	94,48	1 hour	1 hour	1
			7 hours	9
G	91,98	2 hours	6 hours	1
			7 hours	10

Working Period

The results of univariate analysis for the working period variable showed that there were 43 respondents (72.90%) out of 59 respondents who had worked in the welding workshop for <5 years and 16 respondents (27.10%) who had worked in the welding workshop for ≥5 years (Table 1).

Table 3. Distibution frequency of working period

Working Period	Frequency (n)	Percentage (%)
≥5 years	16	27,10
<5 years	43	72,90

Uses of Ears Protection Equipment (EPE)

The results of observations in the study showed that all respondents did not use EPE while working. The distribution of noise exposure among respondent distributed is presented in Table 2.

Difference of average noise intensity on workers with and without NIHL

Test normality test of noise intensity was carried out with the Kolmogorov-Smirnov test and showed a p-value= 0.010 ($p < 0.05$). This value indicates that the data is not normally distributed. The results of the analysis by the Mann-Whitney test showed the p-value = 0.185 ($p > 0.05$) which shows that there is no significant difference from average noise Intensity between workers who experience NIHL do not experience NIHL or hypothesis is rejected. These results are presented in Table 4.

Table 4. Difference of average noise intensity in workers with and without NIHL

NIHL	Noise Exposure (dB) Mean	P value
Yes	94,78	0,185
No	93,58	

Association between duration of noise exposure and working period with NIHL

Cross tabulation in Table 5. showed that 24.60% of respondents who were exposed to noise >TLV experienced NIHL and that 50,0% of respondents who had worked in a welding workshop for ≥5 years experienced NIHL, while 86.0% of respondents who have worked in a welding workshop for <5 years have normal hearing or do not experience NIHL. The results of bivariate analysis to determine the association between duration of exposure with the NIHL shows that there was no significant association (p-value=0.579), but there was significant association between working period with NIHL p-value= 0.007)

Table 5. The association between exposure duration and duration of work with NIHL

Occupational Factors	NIHL				p-value
	Yes		No		
	n	%	n	%	
Duration of exposure					
>NAB	14	24,6	43	75,4	0,579
≤NAB	0	0,0	2	100,0	
Working Period					
≥5 years	8	50,0	8	50,0	0,007
<5 years	6	14,0	37	86,0	

DISCUSSION

The prevalence of NIHL in this study was 23.70%, which was slightly lower than the previous study on automobile sector workers in China, which was 28.82% lower [12]. Tinnitus and ear pain are common concerns among respondents. It indicates an increase in hearing sensitivity. The study's findings, which revealed that bilateral NIHL was more common than unilateral NIHL in each ear, support the characteristics of NIHL that typically occur bilaterally. The phenomenon is more prevalent since noise exposure affects both ears of workers [7]. Meanwhile, unilateral NIHL episodes typically occur when the position of the head becomes protective against one of the ears or if one ear is more susceptible to noise [13].

Noise intensity are acquired by measuring noise intensity at a single point in time during the 6 working day. The average of the measurement findings is used to calculate

how much noise exposure workers get. The results revealed that all workers were exposed to noise levels greater than 85 decibels, with a median exposure intensity of 93.37 decibels. The maximum period of work in an environment with noise levels of 93.37 decibels before the risk of hearing loss is two hours [2].

Respondents in this survey worked varied from 1 to 7 hours per day. Only 3.60% of respondents experienced noise during ≤TLV. Respondents subjected to noise ≤TLV did not employ APT during work, resulting in no reduction in noise intensity. In addition, respondents' working periods ranged from one to six years. This is connected to the age of workers under 30 years. Workers who have prior experience working in welding workshops are more likely to start their own welding workshop business, resulting in an average working period of 3.27 years.

The findings of bivariate analysis to determine the average difference in noise intensity between those who experienced NIHL and those who did not experience NIHL revealed that there was no significant average difference between the two groups. This contradicts the theory that noise exposure above 85 decibels may decrease the hearing sensitivity. The definition of NIHL is an increase in auditory threshold with a pathognomonic indication of notching ≥25 dB at 3000 - 6000 Hz [14].

Results of the bivariate analysis to investigate the association between the duration of noise exposure and the prevalence of NIHL. There is a possibility that the respondent did not suffer irreversible hearing loss. The audiometric examination for this study was performed in the morning before the personnel were exposed to noise. This procedure is performed to ensure that there is no reversible hearing loss, as the bent cilia can still return to normal within 16 to 36 hours [15], [16]. In addition, the characteristics of respondents were less diversified to show a meaningful association (just two respondents had a duration of exposure <TLV.

Bivariate analysis to determine the relationship between the working period and NIHL among welders in this study showed a significant association. These results are in line with the theory that continuous exposure to noise for a long period of time can cause high hearing damage compared to impulsive exposure [7]. The average working period of respondents with NIHL was 4.14 years or higher than the average working period of respondents without NIHL, which was 3 years. In addition, the results of this analysis also show that there is an influence of age differences in those who experience NIHL and those who do not experience NIHL. The average age of respondents who experienced NIHL was 29.57 years. This figure is higher than the average age of respondents with normal hearing, which is 26.13 years. This study also figured out respondents whose working period of <5 years but experiencing NIHL, in depth interview were conduted to this 6 respondents and found that there were factors outside work that affects the occurrence of NIHL, 4 out of 6 of the respondents have a hobby of listening to loud music or playing musical instruments.

CONCLUSION

Prevalence of NIHL among welder in Bandar Lampung is 23.70 with range of noise exposure intensity of 89.12 – 99.77 dB, noise exposure duration of 1 – 7 hours per day, and working period of 1 – 6 years. There was no significant difference between the average intensity of noise exposure in the workplace in welders who experienced NIHL and did

not experience NIHL. There is no significant association between the duration of noise exposure, while there was a significant relationship between working period and NIHL among welders. an effective hearing concervation program is urgently needed to prevent NIHL in workers who work in noisy environtment.

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