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Noise exposure and hearing threshold levels of rice mill workers

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ABSTRACT

Industrial noise is generally one of the risk factors for occupational and environmental safety and health. Noise is a risk factor for decreased hearing threshold value in addition to other factors such as age, working period. This study used a cross-sectional design that aimed to identify the hearing threshold level (HTL) of rice mill workers exposed to hazardous noise in Karanganyar Regency, and investigate the relationship with other factors such as age, tenure. Audiometric data from 92 participants were collected through audiometric examination by qualified personnel using an audiometer in a quiet environment. The test was conducted after the participants had rested completely for >14 hours after their last exposure to workplace noise. The results showed that all participants had worked in a noise-hazard work zone for >1 year. The participants' ages ranged from 28 to 57 years. The average hearing threshold in the right ear was 36.71 dB and the average hearing threshold in the left ear was 39.55 dB. The hearing loss associated with work experience was greater than that caused by noise intensity age. Noise intensity, age and working experience were significant to the workers' ear hearing threshold values. Multivariate test results show that noise intensity is the most influential factor (>60%) on HTL. HTL among industrial workers should be assessed regularly. At the health policy level, these workers need to start being protected when they start working.

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1. INTRODUCTION

Continued noise exposure can result in permanent hearing loss. Noise is a hazardous factor for safety and health at work and the environment because it causes hearing loss caused by Noise-induced hearing loss (NIHL). Today, it is recognized that noise harms workers' health in various fields of work [1]. Health problems caused by noise can be categorized as Hearing impairment, such as hearing loss, damage to the ear and hearing nervous system, and non-hearing disorders, such as insomnia, stress, reduced concentration, difficulty communicating, and discomfort [2]. The intensity of the noise in the workplace will increase with more noise sources at work. The distance between the source of sound and the workforce also affects the level of sound intensity received. The intensity of sound the workforce receives will decrease if the distance from the sound source increases, and vice versa [3]. NIHL caused by prolonged exposure to workplace noise is characterized by sensory neural hearing loss, in which long-term continuous noise exposure leads to a loss of the ability to hear well in both ears [4]. A single very loud voice exposure or long exposure to loud voices can lead to hearing loss. Long-term loud exposure can damage cells and membranes in the cochlea, thereby damaging hair cells

[5]. NIHL is a type of progressive sensorineural hearing impairment caused by noise exposure. The WHO estimates that 10% of the global population is exposed to noise pollution, and 5.3% have NIHL [6], [7]. Approximately 16% of adult hearing loss cases are associated with exposure to workplace noise [8], [9].

About 12% of the working population in the United States has hearing difficulties, and about 24% of them are caused by exposure to noise at work. The United States population exposed to hazardous workplace noise reached 22 million [6]. Noise-Induced Deafness (NID) accounted for >60% of all illnesses in Norway. From 2002 to 2005, 16.2%-22.9% of Korean workers were exposed at workplaces to noise exceeding 85 dB(A), and 4,483 workers experienced NID [10]. The prevalence of professional NIHL in China is estimated at >20%. In some low/medium-income countries, workers exposed to noise in the transportation and manufacturing industries and informal industries such as pear grinding have a high prevalence of NIHL incidents, ranging from 18% to 67% [6], [11]. Hearing ability may decrease as you age, and NIHL usually develops slowly due to repeated voice exposure. However, the progression of hearing loss is usually fastest during the first few years of exposure [9], [12].

A preliminary study of noise exposure and hearing loss in steel industry workers in Thailand found a significant correlation between voice exposure to hearing threshold values and individual characteristics such as age and age [9], [13]. The research on noise that is widely available is more limited to the effect of noise exposure on blood pressure and occupational stress. However, research on the impact of noise on hearing threshold level (HTL) still needs to be completed in Indonesia. HTL in informal industry workers has yet to be studied widely. An understanding of the factors associated with HTL needs to be improved. Besides that, multivariate tests that look at the influence of other factors besides noise on HTL have not been widely used, so this study aims to see the effect of noise, age, tenure, and length of work with HTL in rice factory workers in Karanganyar Regency.

2. METHOD

This study used a cross-sectional research design. The sampling technique used was total sampling, meaning that all workers across 25 rice mills were eligible as research samples. A total population of 95 respondents was used as the research sample. Audiometric data from 95 participants working in zones with noise levels >85 dB(A) from 25 rice mills in Karanganyar Regency were used in statistical analysis. Demographic data of participants and personal protective equipment (PPE) use were obtained through questionnaires. Audiometric measurements were performed with audiometers on 95 participants in a quiet environment, and a qualified occupational nurse examined HTL. The same examiner examined all participants to ensure consistency. Tests were conducted after participants had fully rested for ≥14 hours following their last exposure to workplace noise. Audiometry measurements were performed for 1 hour on each respondent to obtain valid results.

Noise measurement uses a calibrated sound level meter. Researchers conducted field calibration before and after sampling. The noise level meter was set at 85 dB(A) as the threshold for workers. The researcher did the noise level measurement once during the eight-hour working time because the production process was done consistently based on SNI 7231:2009. The determination of noise measurement points using the grid method is done by giving a distance at each point in each station so that a certain area is formed. Each measurement point must be parallel to the other measurement points, so it is described as a square, and each point in the corner is a measurement point. The sound level meter is laid as high as 1.5 meters from the ground, and a tripod is used as a tool. The sample location is displayed in Figure 1. This research location was selected because it is the district's center of rice agricultural products. The research ethics protocol was approved by the health research ethics committee of Dr. Moewardi Solo Regional General Hospital with number 187/I/HERC/2020.

3. RESULTS AND DISCUSSION

Karanganyar Regency is a district located in the Central Java Province. It is recognized as one of the agricultural hubs on the island of Java. Within Karanganyar Regency, Kerjo District is a sub-district that plays a crucial role in supporting agricultural output. The predominant occupation among the populace residing in Kerjo District is agriculture. Engaging in agricultural work undoubtedly entails health hazards. One of the hazards pertains to farmers who are concurrently employed in rice mills. Rice milling, being an agricultural occupation, poses dangers and hazards to the health of workers. Risk factors may arise from the surrounding environment, the specific work environment, or the nature of the work itself. The excessive intensity of noise emitted by production machinery is identified as one of the environmental risk factors.

The demographic characteristics of the participants and the factors that were selected are presented in Table 1. Both male and middle-aged volunteers were included in the study, with a mean age of 47.12 years and a standard deviation of 6.72 years. The duration of their job ranged from 1 to 14 years, with a mean of 7.28 years and a standard deviation of 2.988 years. Furthermore, around 16.3% of the participants had experienced noise dangers in their workplace for a duration of less than five years, while 83.7% had been exposed to noise for a period of more than five years. The typical workweek consisted of 35 hours (standard deviation=7.702) and involved significant amounts of noise exposure. High noise levels were characterized as loud levels that elicited

shouting in order to be audible to individuals in close proximity, but not in direct proximity. Under regular working conditions, the participants reported an average noise exposure of at least eight hours per day, six days per week.

Figure 2 illustrates the diverse outcomes of noise measurements conducted on all participants, despite their same geographical location. The noise intensity exceeds the threshold value. The disparity in noise measurement outcomes can be attributed to the varying proximity of respondents to the noise source. Based on the measurement results, noise levels are all >NAB with an average noise of 96, 93 dB(A). The highest noise is 106 dB(A) and the lowest is 91 dB(A).

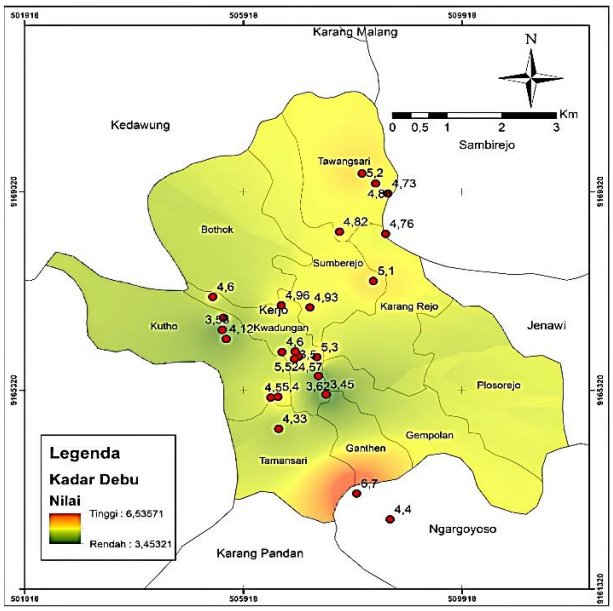

Figure 1. The sampling point location at Kerjo Subdistrict

Table 1. General characteristics of research respondents

Variable	Mean±SD	N (92=100%)
Age (Range=28-57)	47.12±6.727	92 (100%)
Gender (Male)		92 (100%)
Duration of work (Range=2-14 Years)		
<5 years	7.28±2.988	15 (16.3%)
≥5 years		77 (83.7%)
Noise induced threshold level		
Right ear	36.71±11.173	92 (100%)
Left ear	39.55±11.590	92 (100%)
Length of employment	35.00±7.702	92 (100%)

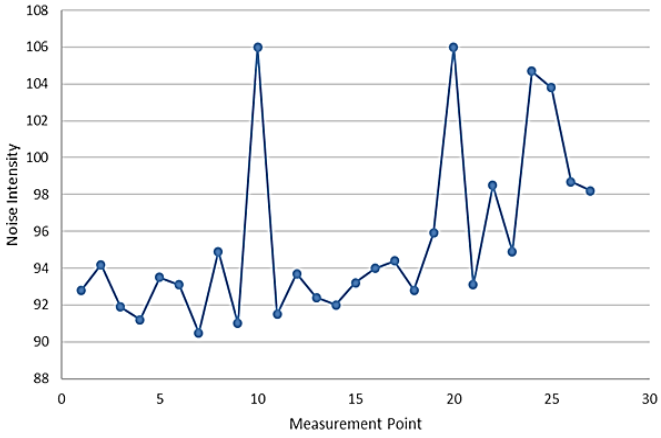

Figure 2. Noise Intensity in the location

Table 2 shows the results of the Spearman correlation, The use of the spearman correlation test is because the data scale uses an ordinal data scale. Normal (N), mild deafness (MD), moderate deafness (MOD), and severe deafness (SD) for each category of participants. The HTL of all participants was divided into two groups. Table 2 displayed the increasing age of workers in the work zone, and noise hazard was associated with higher HTL at the frequency of 46-55 years with p=0.0001 and p=0.001 in both ears therefore, spearman correlation test was used to estimate the relationship between hearing loss and different groups of participants.

Table 3 shows the results of the Spearman correlation N, MD, MOD and SD for each category of participants the working period of rice mill workers, where a working period of 6-10 years has the highest noise impact with 42 respondents experiencing mild deafness and moderate deafness, and for a working period of 0-5 years there are 16 respondents who have mild and moderate deafness. However, for a working period of 11-15 years there were 14 people who experienced mild deafness (1), moderate deafness (7) and severe deafness (6) respondents. Table 3 presents the coverage of hearing loss by length of service and average age of participants. The prevalence of hearing loss among those with longer tenure is much higher compared to workers with less tenure. This suggests that a longer duration of employment is associated with greater hearing problems.

Results of the Spearman correlation test between noise intensity and hearing threshold value where the test results are significant by having a correlation value (r) of 0.447 and 0.447 which shows the higher the noise intensity, the more respondents have a risk of experiencing hearing threshold values in the deaf category as can be read in Table 4.

Based on Table 5 with linear regression test. The multivariate test is used to identify the most influential independent variable and measure the strength of the influence of the variable on the dependent variable, it is known that the behavior of length of service, and age simultaneously affects the right ear hearing threshold value (p-value < 0.05). The proportion of the influence of the independent variables on the dependent variable is 62.2% (R-square=0.622), while the rest is influenced by other variables not included in the regression test. Based on the regression coefficient value, the noise intensity variable affects the right ear hearing threshold value compared to the variables of the working period, age, and working week. This is because the regression coefficient value of noise intensity is greater than the other regression coefficients. The results of the multiple regression coefficient calculation above show the noise intensity concentration coefficient value of 0.580 so that it can predict 58.0% of the right ear hearing threshold value.

Table 2. Spearman correlations test for age and hearing threshold level of subjects

Variable	Right ear				p-value	Left ear				p-value
Age	N	MD	MOD	SD		N	MD	MOD	SD	
26-35	6	1	1	0	0.0001	6	1	1	0	0.0001
36-45	5	12	7	3		5	12	4	3	
46-55	4	20	26	0		3	18	29	0	
56-55	0	4	3	3		0	4	3	3	

Table 3. Spearman correlation test for length of employment and hearing threshold level of subjects

Variable	Right ear				p-value	Left ear				p-value
length of service	N	MD	MOD	SD		N	MD	MOD	SD	
0-5	14	13	3	0	0.0001	14	10	6	0	0.0001
6-10	1	23	24	0		0	24	24	0	
11-15	0	1	10	3		0	1	7	6	

Table 4. Spearman correlation test for noise intensity and hearing threshold level of subjects

Bivariate test	p-value	Coefficient correlation (r)
Environmental noise intensity with right ear hearing threshold value	0.0001	0.488**
Environmental noise intensity with left ear hearing threshold value	0.0001	0.476**

Based on Table 6 with linear regression test, the multivariate test is used to identify the most influential independent variable and measure the strength of the influence of the variable on the dependent variable. it is known that the behavior of length of service, and age simultaneously affects the right ear hearing threshold value (p-value<0.05). The proportion of the influence of the independent variables on the dependent variable is 62.7% (R-square=0.627), while the rest is influenced by other variables not included in the regression test. Based on the regression coefficient value, the noise intensity variable affects the right ear hearing threshold value compared to the variables of the working period, age, and working week. This is because the regression

coefficient value of noise intensity is greater than the other regression coefficients. The results of the multiple regression coefficient calculation above show the noise intensity concentration coefficient value of 0.629 so that it can predict 62.9% of the left ear hearing threshold value.

Table 5. Multivariate analysis test for noise intensity and hearing threshold level of right ear subjects

Model		Anova test		Determination coefficient test		Regression coefficient	Sig.
		F	Significant	R-square	Adjusted R-square		
1	(Constant)						.004
	Length of employment (week)					.011	.871
	Age	35.830	0.000			.209	.008
	Length of service					.577	.053
	Noise intensity			0.622	0.605	.159	.000
2	(Constant)						.003
	Age	48.299	0.000			.210	.007
	Length of service					.158	.052
	Noise intensity					.580	.000

a. Dependent variable: NIHL

Table 6. Multivariate analysis test for noise intensity and hearing threshold level of left ear subjects

Model		Anova test		Determination coefficient test		Regression coefficient	Sig.
		F	Significant	R-square	Adjusted R-square		
1	(Constant)	36.550	0.000	0.627	0.605		.014
	Length of employment (week)					.003	.969
	Age					.167	.032
	Length of service					.134	.098
	Noise intensity					.628	.000
2	(Constant)	49.291	0.000				.011
	Age					.167	.029
	Length of service					.134	.096
	Noise intensity					.629	.000

a. Dependent variable: NIHL

The study findings indicated that steel industry workers situated in the higher noise zone exhibited a significant susceptibility to developing NIHL due to their exposure to noise levels ranging from 91.79 to 96.07 dB(A). The findings indicated that the noise levels within the rice milling plant exhibited variation throughout different parts. However, it was observed that all participants in their respective groups experienced a noise exposure level exceeding 85 dB(A). The results indicate that employees experience excessive exposure to noise levels throughout their work shifts. Furthermore, the steelworkers in this study had an average weekly working hour of 35.00 (SD=7.702) hours, which may significantly contribute to their exposure to excessive levels of noise, as advised by OSHA. The permissible limit for worker exposure is 85 dB(A) for a duration of eight hours. The high prevalence of hearing loss among rice mill workers in this study, over 70%, may be attributed to the recommendation by OSHA that worker exposure should not surpass 85 dB(A) for a duration of eight hours per day. This study aligns with the findings of prior research by Kerdonfag, which indicate that occupational NIHL predominantly manifests at elevated levels of intensity [9]. Exposure to loud noise either once or for an extended period can result in hearing loss. Prolonged and continuous noise exposure can lead to gradual and irreversible hearing loss in both ears. The study revealed that workers who were exposed to the substance experienced indications and symptoms of hearing loss more frequently than individuals who were not. These differences were statistically significant, particularly in relation to tinnitus. The findings presented in this study are incongruent with prior research by Mensa-Yawson *et al.* [14]. Tinnitus can potentially arise as a result of prior occupational exposure to high levels of noise [15], [16]. Conversely, ear infections may arise following an ear injury that results in the release of pus within the ear [17]. Nevertheless, additional factors that increase the likelihood of experiencing hearing loss encompass advanced age, familial background, otitis media, contact with auto-toxic medications like aminoglycosides and nicotine, and exposure to high-decibel sounds [18].

In order to prevent hearing impairment, the National Institute for Occupational Safety and Health (NIOSH) imposes a maximum limit of 85 dB(A) for the working display. The Industrial Hygiene Conference of the United States Government suggested that a noise exposure level of 85 dB(A) during eight working hours should be set as a threshold value to safeguard workers from hearing impairment. According to OSHA guidelines, it is recommended that noise exposure should not surpass 90 dB/A during a period of eight hours while working. Additionally, Indonesian regulations specify that the level of action should be set at 85 dB(A) for the same duration. Furthermore, our findings indicate that the average hearing threshold (HTL) is higher in

the left ear compared to the right ear, which aligns with previous research findings by Kerdonfag [9]. This disparity could be attributed to the heightened sensitivity of the left ear or the increased noise exposure experienced by workers [19].

This study aimed to evaluate the frequency and factors associated with hearing impairment among individuals engaged in peat-grinding activities within the Karanganyar district. The majority of participants in this study had symptoms of noise-related morbidity, with around 84% of them experiencing a disruption in one ear during the audiometric examination. These findings are unsurprising due to the elevated noise levels in the facility, indicating that workers' hearing health has been impacted by exposure. In this study, the occurrence of noise-related symptoms among respondents was 84.2%, which was greater than the incidence among factory workers in Ghana but significantly lower than in Ilorin, Nigeria [14], [20]. In this study, factors related to HTL found that >50% of the factors were due to noise and the rest were due to other factors. The incidence of noise-related symptoms among respondents was 84.5%, which is greater than the incidence among factory workers in Ghana but significantly lower than that in Ilorin, Nigeria [14], [20]. The observed discrepancy between the results of this study and the results obtained in the steel mill could possibly be attributed to the scale of the industry, as it is anticipated that larger-scale companies would have more well-structured occupational health services. In addition, variations in the results of this study could be attributed to differences in the duration of exposure and the number of working hours per day [7]. About 17% of employees had problems with one ear. Although alarming, this result may be surprising given the high volume of noise during rice milling. The influence of noise on hearing is typically more pronounced on the right side, mostly due to the protective effect of the head's shadow and the fact that the right ear experiences a greater magnitude of noise impact compared to the left ear. Contrary to our research findings, there is no substantial difference observed between the two ears. The level of disturbance observed by this worker is predominantly moderate.

All individuals who took part in this study were male. They engage in extended periods of work. According to the NIOSH Institute, these workers are exposed to excessive noise. The study's findings indicate that being over the age of 40 is a risk factor for hearing damage. Azess's research findings also demonstrated a robust association between HTL and age. Their findings demonstrated a more rapid increase in HTL among those aged 30 and above, particularly at frequencies that have a significant correlation between hearing impairment and age. The research findings indicated a positive association between the duration of employment exceeding five years and the exacerbation of NIHL. The prevalence of hearing impairment continues to rise. At elevated levels of noise exposure, impulsive noise appears to pose a greater risk to auditory health. The study found that workers frequently lacked protection against continuous or impulsive noise levels exceeding 90 dB(A), resulting in a higher prevalence of hearing impairment. In addition, they work a total of 60 hours per week, which exceeds the recommended duration [21]–[23].

All participants in this study engage in smoking. Smoking is a well-established risk factor for numerous diseases and has previously been linked to hearing loss. Consequently, it is unsurprising that grinding workers had a twice-higher probability of experiencing morbidity symptoms associated with noise and hearing impairment [24], [25]. Hence, the implementation of a smoking cessation program will effectively tackle this issue. The prevalence of noise-related morbidity symptoms among workers was found to be five times higher than that of hearing impairment, suggesting a greater ability to predict hearing impairment compared to symptoms associated with ordinary hearing loss. The most effective remedy for industrial noise in the context of NIHL is the implementation of engineering or administrative controls aimed at eliminating or lowering noise. To mitigate the risk of NIHL, it is advisable to decrease the noise level to a level below 80 dBA. In order to safeguard workers against hearing loss, numerous nations have established a legal requirement for occupational noise exposure at a level of 85 dBA [6], [26]. Furthermore, noise exposure can lead to many health consequences such as elevated blood pressure, heart rate, stress, and disrupted sleep [4], [27]–[30].

4. CONCLUSION

Noise intensity is the main factor that causes a decrease in NIHL in rice mill workers in Karanganyar Regency. However, other factors such as length of service, length of employment and age are some of the supporting factors in increasing the risk of NIHL. Workers' age, working period, and noise intensity significantly affect the hearing threshold value. The HTL of industrial workers should be assessed regularly, and the protection of informal workers needs serious attention. Noise exposure in the workplace can be minimized by efficient control measures such as engineering control, administrative control, and PPE. A complete hearing conservation program, including education, audiometric examination, working time regulation, and PPE use, is the most feasible way to protect industrial workers from general workplace noise in developing countries.

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