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Research Article

THE RELATIONSHIP BETWEEN THE OCCUPATIONAL FACTORS AND HEARING IMPAIRMENT IN PT. BINDER INDONESIA WORKERS

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ABSTRACT

Background: Industrial noise exposure is a significant occupational hazard, with prolonged exposure leading to irreversible noise-induced hearing loss (NIHL). This study examines the relationship between occupational factors (noise exposure, work tenure, hearing protective device usage, and worker age) and hearing impairment among production workers at PT Binder Indonesia, a manufacturing company with high-intensity noise levels (90–100 dBA).
Methods: A cross-sectional analytic study was conducted with 176 male workers aged 20–65 years, exposed to ≥85 dBA noise for ≥5 years. Data were collected through noise level measurements (Sound Level Meter), hearing tests (Rinne, Weber, Schwabach), and questionnaires. Statistical analysis included chi-square tests and prevalence ratios (PR) with 95% confidence intervals (CI) using SPSS.
Results: Hearing impairment was prevalent in 60.2% of workers. Significant relationships were found between work tenure >5 years (PR=1.640; 95% CI: 1.174–2.291; *p*=0.001) and age ≥40 years (PR=0.725; 95% CI: 0.576–0.913; *p*=0.014). Noise exposure (>85 dB) and hearing protective device usage showed no significant relationship (*p*>0.05).
Conclusion: Long work tenure increases NIHL risk, while older age may have a protective effect, possibly due to adaptive measures. Despite high noise exposure, consistent use of protective devices did not significantly reduce impairment, suggesting the need for improved compliance and workplace interventions.

Keywords: *Hearing impairment, Industrial noise, Occupational health, Equipment, Work*

INTRODUCTION

The industrial sector plays an important role in supporting the economy by producing goods and services. In the modern era, machinery has become the backbone of industrial operations to increase efficiency and productivity. However, the negative impacts of industrialisation, such as noise pollution, are often overlooked. With prevalence rates ranging from 21.7% to 34.5%, industrial noise exposure, particularly from production equipment, can cause hearing loss (1). This phenomenon has become a global problem that requires serious attention considering that long-term exposure to high-intensity noise can cause permanent hearing loss.

Noise, according to the regulation of the minister of labor and transmigration number per.13/men/x/2011-year 2011 regarding the limit values of physical and chemical factors in the workplace, is defined as any unwanted sound that results from production process equipment and/or work equipment that, at a certain level, can cause hearing loss. In an industrial context, noise is divided into two categories: interior (e.g. production machinery) and exterior (e.g. construction equipment). Noise exposure above the Threshold Limit Value (TLV) of 85 dBA for 8 h/day, according to Minister of Health Regulation No. 70/2016 on Standards and Requirements for Industrial Work Environment Health, can result in noise-induced hearing loss (NIHL), which reduces the quality of life of workers. This disorder is irreversible; therefore, prevention through environmental control and use of personal protective equipment (PPE) is crucial.

World Health Organization data show that 360 million people in the world have hearing loss, with 91% of them being adults. The Southeast Asian region, including Indonesia, has a significant prevalence owing to massive industrialisation. It is estimated that 8.9 million Indonesians over ten suffer from hearing loss. One of the main causes of impairment, especially for males aged > 60 years, is deafness, and many deaf people deal with other disabilities and mental health problems (2), while Basic Health Research in year 2013 recorded 2.6% of cases of work-related hearing loss. The main factors include chronic noise exposure, age, tenure, and noncompliance with PPE use (3). These findings emphasise the urgent need to address noise risks in industrial environments.

Previous studies identified that workers aged >40 years with a working period of >10 years and exposure >8 h/day were most susceptible to NIHL (4). There is a significant relationship between the age, working period, and hearing threshold value of workers, which indicates that high noise exposure and long working period contribute to the decline of hearing loss (5). This condition is exacerbated by low awareness of earplugs or earmuffs, even though the company has provided them. Therefore, the analysis of risk factors such as worker characteristics, duration of exposure, and PPE compliance needs to be studied in greater depth.

PT Binder Indonesia, as a manufacturing company supporting the oil, gas, and mining industries, uses high-intensity noise machines, such as cutting wheels, bar bending, and grinding machines. A preliminary study of 24 production workers revealed that 58% of them had decreased hearing quality. This finding is in line with the company's internal report which states that noise in the production area reaches 90-100 dBA, which exceeds the NAB. If not controlled for, the long-term impact will increase the economic burden

due to health compensation and decreased productivity.

MATERIAL AND METHODS

Reseach Design

This study employed a cross-sectional analytical design to investigate the relationship among occupational factors (noise exposure, work tenure, hearing protective devices, and workers' age) and hearing impairment in PT Binder manufacturing line workers. An overview of potential risk factors is provided by the cross-sectional design, which enabled the simultaneous measurement of the exposure variables and outcome (hearing impairment) at a single point in time.

Participation Selection

Based on Lemeshow's two-sided sample size estimation for a hypothesis-testing scenario, 176 respondents participated in the study. The subjects were selected based on strict inclusion criteria, which included being male employees aged 20–65 years, having a regular work schedule of eight hours per day, and having been exposed to noise levels at work of at least 85 dBA for at least five years. To evaluate the potential hearing effects without confounding effects from non-occupational sources of hearing loss, such as age-related hearing loss, the criteria ensured that the study population had experienced noise exposure for a sufficient amount of time.

Data Collection

Data were gathered from primary and secondary sources. Three crucial components were used in the primary data collection process: structured interviews, hearing tests, and noise level measurements. A Sound Level Meter (SLM) was used to measure the noise levels in accordance with the industrial noise level measuring standards outlined in Minister of Health Regulation No. 70/2016 regulations. Rinne, Weber, and Schwabach tuning fork tests were used to assess hearing function.

Statistical Analysis

SPSS software was used to analyse the data. Univariate analysis was first performed to generate frequency distributions for each variable and provide a summary of the dataset. The next stage was bivariate analysis, which examined the relationships between categorical variables, such as noise exposure and hearing impairment, using the chi-square test. The Prevalence Ratio (PR) and 95% Confidence Interval (CI) were used to assess the strength and direction of the connections.

RESULTS

Table 1. Distribution of Workers by Hearing Impairment and Occupational Factors.

Variable	Category	N	%
Hearing Impairment	Impaired	106	60.2
	Not Impaired	70	38.8
Noise Exposure	>85 dB	117	66.5
	≤85 dB	59	33.5
Work Tenure	>5 Years	121	68.8
	≤5 Years	55	31.3
Hearing Protective Devices	Unprotected	70	39.8
	protected	106	60.2
Worker's Age	≥40 Years	110	62.5
	<40 Years	66	37.5

Based on the results of the study, the majority of respondents experienced hearing impairment (60.2%), with noise exposure levels >85 dB in 66.5% of the respondents. A total of 68.8% of workers had a working tenure of more than 5 years, and 62.5% were ≥40 years old. Although most workers used hearing protection (60.2%), there was still a significant proportion of unprotected

workers (39.8%). This distribution indicates the potential for high exposure to risks of hearing impairment in the studied work environment.

Table 2. Relationship between Noise Exposure, Work Tenure, Hearing Protective Devices, worker's Age with Hearing Impairment

Occupational Factors	Hearing Impairment		*p-value*	*Prevalence Ratio*	95% *CI*	
	Impaired	Not Impaired			Lw	Up
Noise Exposure						
>85 dB	70	47	1.000	0.981	0.762	1.262
≤85 dB	36	23				
Work Tenure						
>5 Years	83	38	0.001	1.640	1.174	2.291
≤5 Years	23	32				
Hearing Protective Devices						
Unprotected	48	22	0.093	1.253	0.991	1.585
Protected	58	48				
Worker's Age						
≥40 Years	58	52	0.014	0.725	0.576	0.913
<40 Years	48	18				

The results of the test of the relationship between occupational factors and hearing loss show that a working period of >5 years has a significant relationship with the incidence of hearing impairment (p = 0.001) with a prevalence ratio of 1.640 (95% CI: 1.174-2.291). This means that workers with more than five years of service have a 1.64 times greater risk of hearing loss than those with ≤ five years of service. Age also showed a significant relationship (p = 0.014), where workers aged ≥40 years had a lower risk of hearing loss (PR = 0.725; 95% CI: 0.576-0.913). However, noise exposure and the use of hearing-protective equipment did not show a statistically significant relationship with hearing loss in this population.

DISCUSSION

Relationship between Noise Exposure with Hearing Impairment

The results of bivariate analysis in this study showed that there was no significant relationship between noise exposure above 85 dB and hearing impairment in respondents, with a p-value of 1.000 and a prevalence ratio (PR) of 0.981. This finding is not consistent with the results of previous studies. Noise-induced hearing loss is common in sectors where exposure to noise is frequent, such as mining, construction, and manufacturing. A significant proportion of employees in these industries have significant hearing impairments (6). This difference in results indicates that there are other factors that may influence this relationship.

One factor that is thought to be the cause of this insignificance is the use of hearing protective devices (HPD) by most workers. The data show that, although 66.5% of workers are exposed to high noise, only 60.2% use hearing protective devices while working. To reduce the amount of sound that affects the eardrum, personal hearing protection devices are barriers made to protect the ears from loud noises. These devices offer cost-effective ways to stop hearing loss induced by extended exposure to loud noises (7). Therefore, the impact of noise becomes less visible in the statistical analysis results.

In addition, the noise measurement method used in this study could potentially have affected the results. The use of a sound level meter (SLM) is only performed in one measurement time and not continuously; therefore, it most likely does not represent cumulative noise exposure (8). Another factor is the individual characteristics of the workers, such as worker's age, which can also affect the results. The majority of respondents (62.5%) were ≥40 years old, so they may have experienced presbycusis or hearing loss due to the aging process, which can obscure the specific effects of noise exposure on hearing loss (9).

Relationship between work tenure with hearing Impairment

The results showed that a working period of ≥5 years was a significant risk factor for hearing impairment, with a p-value of 0.001 and a prevalence ratio (PR) of 1.640. This finding is consistent with those of previous studies by Fuentes-Santamaría, Prolonged exposure to noise causes degenerative changes in cochlear structures, oxidative stress, inflammation, and impaired sodium/potassium activity(10). Exposure to workplace noise for >10 years increases the likelihood of hearing loss and moderate to severe hearing loss in older adults (11). This means that the longer a person works in a noisy environment, the greater the risk of hearing loss.

The cumulative effect of noise is the main explanation for this relationship. Prolonged exposure to noise above the threshold (>85 dB) permanently damages the fine hair cells in the cochlea (12). In this study, 68.8% of workers had a working period of ≥5 years, so their exposure was longer, and the possibility of hearing damage was higher. This condition is exacerbated by the absence of work rotation, as revealed from interviews with respondents who stated that they work in the same area for a long time without any displacement or respite from noise exposure.

The lack of job rotation prevented workers from recovering from noise exposure. Timur Vasil, et al., mentioned implementing an integrated noise management strategy that includes engineering controls and job rotation can significantly reduce noise levels in rubber factories and improve worker health, safety, and productivity (13). In addition, the results of this study are also in line with a study by Rodrigues Da Silva, et al., which found that two key periods have been identified for the detection of hearing loss in workers exposed to noise: the first year of employment and the time following the third year (14). The similarity in these findings strengthens the conclusion that a long duration of noise exposure is an important factor in the occurrence of hearing loss in industrial workers.

Relationship between Hearing Protective Devices (HPD) with Hearing Impairment

The results showed that the use of hearing protective devices (HPD) did not have a statistically significant relationship with hearing impairment (p = 0.093). Nonetheless, the data showed that workers who did not use HPD had a 1.253 times higher risk of hearing impairment than those who did. The insignificance of this relationship could be due to various factors that affect the effectiveness of ear protective equipment in field practice.

One of the main factors is the low compliance of workers who consistently use HPD. In this study, only 60.2% of workers routinely used HPD while working, and weak supervision from management was the main cause of this noncompliance. In addition, the quality of the HPD used can also be a contributing factor, as HPD that is not up to the standard or does not fit workers' ears will not provide maximum protection. This is reinforced by the report of the Ministry of Health (2010) which highlights the importance of HPD suitability and feasibility, with a noise threshold standard of 85 dB.

The differences between the results of this study and those of previous studies are also important. For example, Hamzah at PT Japfa Comfeed found a significant relationship between HPD use and a reduced risk of hearing loss (p = 0.029) (15), while another study did not find a similar relationship (16). This difference in results is

likely influenced by variations in the type of ear protective equipment used, duration of use, and how well training and socialisation of HPD use is conducted at each work site. Thus, even though the statistical results were not significant, it is important to pay attention to factors that affect the effectiveness of ear protective equipment use in efforts to protect workers' hearing.

Relationship between Worker's Age with Hearing Impairment

The results of bivariate analysis showed a significant relationship between age ≥40 years and hearing impairment (p=0.014), with a Prevalence Ratio (PR) value of 0.725 (95% CI 0.576-0.913). This finding indicates that workers aged ≥40 years have a lower risk of hearing loss than younger workers do. This seemingly counterintuitive result can be explained through several mechanisms. Age-related hearing impairment is therefore highlighted as a common issue, and exposure to noise in the workplace is identified as a significant risk factor. However, these findings indicate that once hearing impairment occurs, it may be stabilized rather than progressively worsened in some individuals (11).

The finding that age ≥40 years is protective contradicts some previous studies. Workers aged between 45 and 65 years are 3.8 times more likely to develop hearing loss compared to those aged 18 to 29 years. In the same way, workers between the ages of 30 and 44 are 2.9 times more likely than younger workers to experience hearing loss (17). This difference may be due to variations in the characteristics of the study population. In this study, older workers may have applied more consistent hearing protection along with their longer work experience. In addition, older workers may have been placed in work positions with more controlled noise exposure compared to junior workers who were often assigned to production areas with higher noise levels.

The results of this study are supported by Soepardi's theory, which states that protective factors in older workers may be related to changes in exposure patterns and physiological adaptations (18). Further studies with longitudinal designs and more accurate measurement methods are needed to confirm these findings and explore the possible protective mechanisms in older workers in noisy environments.

CONCLUTION

The study concluded that more than five years of working tenure was a significant contributing risk factor for the occurrence of hearing loss in industrial workers, indicating that long-term noise exposure has a progressive damaging effect on hearing function. This finding confirms the need for better management of work rotation and strengthening of hearing conservation programs aimed specifically at workers with long working lives. In contrast, age > 40 years showed an unexpected relationship with a protective effect on hearing loss. This may be because of naturally occurring physiological adaptations or safer job placement policies for older workers. These findings leave the field open for further study, particularly longitudinal studies that can more accurately capture the dynamics of hearing changes over time.

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