

Risk of Hearing Impairment due to Noise Exposure among Textile Industry Workers at PT X in 2025

Risiko Gangguan Pendengaran akibat Paparan Kebisingan pada Pekerja Industri Tekstil di PT X Tahun 2025

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ABSTRACT

Occupational noise is one of the main preventable hazards that can seriously affect workers' health and productivity, causing noise-induced hearing loss. This study aims to analyze the relationship between noise exposure, age, and length of service with the level of hearing loss among workers in the textile weaving industry at PT X. This analytical observational study with a cross-sectional design was conducted on 30 workers in the textile weaving industry in Surakarta using purposive sampling techniques. Data were obtained through noise intensity measurements and audiometric examinations. Bivariate analysis was performed using the Spearman Rank test with a significance level of 0.05. The results showed that the average noise level at the workplace reached 90.78 dB, with the highest exposure in Room 5 Ring Line C at 104.78 dB. The correlation test showed a significant relationship between age ($r=0.411$; $p=0.024$) and length of service ($r=0.400$; $p=0.029$) with the left ear hearing threshold value, while noise intensity was not significantly related. This indicates that individual factors and job characteristics such as age and length of service play a more dominant role in hearing loss than variations in workplace noise levels. It is concluded that there is a significant relationship between age and length of service and a decrease in the left ear hearing threshold of workers.

Keywords: Noise, hearing impairment, length of service, age, textile industry

ABSTRAK

Kebisingan kerja merupakan salah satu bahaya utama yang dapat dicegah dan berdampak serius pada kesehatan serta produktivitas pekerja, memicu terjadinya gangguan pendengaran akibat bising. Penelitian ini bertujuan untuk menganalisis hubungan antara paparan kebisingan, usia dan masa kerja dengan tingkat gangguan pendengaran pada pekerja bagian weaving industry tekstil di PT X. Penelitian observasional analitik dengan desain *cross sectional* ini dilakukan pada 30 pekerja bagian weaving industry tekstil di Surakarta menggunakan teknik *purposive sampling*. Data diperoleh melalui pengukuran intensitas kebisingan, dan pemeriksaan audiometri. Analisis bivariat menggunakan uji *Spearman Rank* dengan tingkat signifikansi 0.05. Hasil menunjukkan rata-rata kebisingan di lokasi kerja mencapai 90.78 dB dengan paparan tertinggi berada di Ruang 5 Ring Line C sebesar 104.78dB. Uji korelasi menunjukkan adanya hubungan signifikan antara usia ($r=0.411$; $p=0.024$) dan masa kerja $r=0.400$; $p=0.029$) dengan nilai ambang dengar telinga kiri, sementara intensitas kebisingan tidak berhubungan signifikan. Hal ini mengindikasikan bahwa faktor individu dan karakteristik pekerjaan seperti usia dan masa kerja memiliki peran lebih dominan terhadap penurunan pendengaran dibandingkan variasi tingkat kebisingan lingkungan kerja. Disimpulkan bahwa terdapat hubungan signifikan antara usia dan masa kerja dengan penurunan nilai ambang dengar telinga kiri pekerja.

Kata Kunci: Kebisingan, gangguan pendengaran, masa kerja, usia, industri tekstil

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INTRODUCTION

The Industrial Revolution 5.0 globally marks a new era in which collaboration between humans and advanced technology is at the center of economic and social progress. The use of artificial intelligence and automation systems in production processes can increase efficiency, but also has the potential to increase noise levels in the work environment.¹ This is due to the increased use of automated machines, high-speed equipment, and robotic systems that work simultaneously and continuously to meet production targets. The operation of these high-power, high-frequency machines generates loud noise. Increased automation and complexity of production processes pose new challenges in the implementation of occupational safety and health (OSH), especially those related to the risk of noise exposure in the work environment.²

Globally, the World Health Organization (WHO) reports that occupational noise is one of the leading causes of preventable hearing loss.³ This disorder affects not only health, but also labor productivity and quality of life.⁴ Recent studies show that chronic exposure to noise above 85 dB can cause physiological stress, sleep disorders, and an increased risk of hypertension.⁵ In line with these findings, NIOSH has set a recommended daily exposure limit of 85 dB(A) for 8 hours with a 3 dB exchange rule, whereby every 3 dB increase must be offset by a reduction in exposure duration by half.⁶ Therefore, the issue of noise is no longer considered merely a technical problem, but also a global public health issue.⁷

In Indonesia, industrial technology is also

developing rapidly with the implementation of the Industrial Revolution 5.0 concept in various manufacturing sectors. The integration of automation and digitalization has encouraged the use of modern production machines that generate high noise levels. These conditions have the potential to increase noise exposure and the risk of hearing impairment among industrial workers.⁹ Studies show that unsafe working conditions contribute to 32.25% of workplace accidents, including exposure to noise that exceeds threshold levels.¹⁰ Industrial workers with high noise levels have 1.8 times greater work stress than workers in areas with normal noise levels.¹¹

Long-term exposure to noise in the work environment can cause permanent hearing loss, especially at high frequencies, known as Noise Induced Hearing Loss (NIHL).¹² Loud and continuous noise damages the hair cells in the cochlea, especially in the basal part of the cochlea which maps high frequencies. A typical audiometric profile in workers with NIHL often shows a decrease in hearing threshold at 4 kHz.¹³ In addition to audiometric effects, non-auditory effects such as communication difficulties, increased risk of accidents, decreased concentration, and psychological stress are also commonly found.¹⁴ The WHO notes that 156 million people in Southeast Asia, or about 27% of the population, suffer from hearing loss. Of this number, 49 million are adults under the age of 65 who suffer from hearing loss due to exposure to noise in the workplace.¹⁵ These findings are in line with research by Zhou which shows that NIHL cases are most prevalent among manufacturing



workers and are more dominant among young to middle-aged groups. This condition indicates that industrial noise is a real threat to the health and productivity of the workforce in developing countries, including Indonesia.¹⁶

Some studies in Indonesian industrial areas show that noise intensity in production areas often exceeds the Threshold Limit Value (TLV) of 85 dB.^{17 18} The impact of such exposure is not only hearing loss, but also decreased worker performance and accuracy due to sensory and mental fatigue. This condition emphasizes the urgent need for structured noise control measures through the implementation of engineering and administrative controls, as well as hearing conservation programs.¹⁹ Personal protective equipment (PPE) is the main defense against various potential risks in hazardous work environments.²⁰ Compliance with PPE use is often influenced by supervision and behavior factors.²¹

Based on this description, noise exposure in the work environment remains an important issue in occupational safety and health, especially in the era of the Industrial Revolution 5.0, which demands optimal synergy between humans and technology. Therefore, this study aims to analyze the relationship between noise exposure, age, and length of service with the level of hearing impairment in workers in the weaving industry at PT X.

MATERIALS AND METHODS

This study is an analytical observational study with a cross-sectional design conducted in the textile industry at PT X during July-September

2025. This design allows for the analysis of relationships between variables but cannot determine causality, so the findings are associative. Noise exposure measurements were taken once according to the permitted work schedule, which limited the ability to describe exposure variations in other shifts. The research activities included observation, field data collection in the form of noise intensity measurements, work fatigue levels, and audiometric examinations, as well as data processing and analysis. The research population consisted of all weaving workers exposed to noise during working hours. A total of 30 workers were selected as samples using purposive sampling, based on the inclusion criteria of being an active worker for at least six months, having no history of hearing impairment prior to employment, and being willing to be a respondent through informed consent.

Exclusion criteria included workers who were experiencing flu or ear infections, had additional jobs with noise exposure, or routinely used ear protection outside of company procedures. The sample size of 30 people was not calculated using statistical sampling due to time and access limitations, which limited the generalizability of the research results. The use of purposive sampling has the potential to cause selection bias, which needs to be considered in the interpretation of the findings.

The tools used included a sound level meter, audiometer, and K3 observation sheet to record working conditions. The variables of age and length of service were measured using a personal data questionnaire. The data obtained were analyzed univariately and bivariately to assess the



relationship between worker characteristics (age, gender, length of service) and hearing impairment. The statistical test used was the Spearman Rank test because the data were not normally distributed and the research variables were measured as numerical data. The analysis was performed using SPSS version 27 with a significance level of 0.05 to determine the strength and direction of the relationship between variables.

RESULTS

Table 1 shows that only the right hearing threshold and left hearing threshold are normally distributed. This is indicated by a p-value greater than 0.05.

Table 1. Data Normality Test Results

Variabel	p-value
Right Hearing Threshold	0.423
Left Hearing Threshold	0.331
Age	0.001
Tenure	0.001
Noise Intensity	0.000

Source: Primary Data, 2025

Respondent characteristics are described based on a sample size of 30 respondents by age and length of service. Respondents' ages were calculated from their year of birth to the time of the study. The frequency distribution of age and length of service is presented in Table 2.

Table 2 shows that most respondents were over 40 years old, namely 20 people or 66.7%. The youngest was 19 years old and the oldest was 56 years old. The length of service was dominated by the category of >10 years, with 19 respondents or 63.3%.

Measurements were taken at 6 different locations using a calibrated sound level meter. The sources of noise were production machinery and

equipment such as blow molding machines and ring frame machines. The type of noise generated was continuous noise because it occurred continuously during the 24-hour production process. The noise intensity measurement table is presented in Table 3.

Table 2. Characteristics of PT X Respondents

Type of Characteristics	Total	Percentage (%)
Age (years)		
<30 years old	5	16.7
30-40 years old	5	16.7
>40 years old	20	66.7
Quantity	30	100
Tenure (years)		
<5 years old	7	23.3
5-10 years	4	13.3
>10 years	19	63.3
Quantity	30	100

Source: Primary Data, 2025

Table 3. Noise Level Measurement Data per Location

Location	Noise Sources	Results	Remarks
Ruang 1	Blow Blowing Machine	85.33	Above NAV
Ruang 2	Ring Frame Carding Machine	83.03	Below NAV
Room 3	Ring Frame Drawing Machine	84.43	Below NAV
Room 4	Ring Frame Line A Machine	93.48	Above NAV
Room 5	Ring Frame Line C Machine	104.87	Above NAV
Room 6	Ring Frame Frame Line E Machine	93.53	Above NAV

Source: Primary data, 2025

Noise levels at the six locations measured showed significant variation, with a minimum value of 83.03 dB (Room 2 carding) and a maximum value of 104.87 dB (Room 5 Ring Line C). Overall, the average noise level across all locations was 90.78 dB.

Permenaker No. 25 of 2008 classifies hearing status as normal, mild deafness, moderate deafness, moderate-severe deafness, severe deafness, and profound deafness. The frequency distribution of



the respondents' hearing thresholds is presented in Table 4.

Table 4. Distribution of Right and Left Ear Hearing Loss Categories of Textile Industry Workers, 2025

Category	Right Ear		Skin Ear	
	Total	%	Total	%
Normal	4	13.3	4	13.3
Mild deafness	18	60.0	17	56.7
Moderate deafness	8	26.7	9	30.0
Total	30	100	30	100

Source: Primary Data, 2025

It is known that the majority of respondents had mild hearing loss in the right ear (18 respondents, 60%) and the left ear (17 respondents, 56.7%). Twelve respondents who experienced mild hearing loss in the right ear were exposed to noise above the NAB, as were 13 respondents who experienced mild hearing loss in the left ear.

Table 5. Distribution of Hearing Loss Based on Respondents' Age in the Right and Left Ears

Age	Right Hearing Threshold		
	Normal	Mild deafness	Moderate deafness
<30 years old	1	4	0
30-40 years old	0	3	2
>40 years old	3	11	6
Total	4	18	8
Age	Left Hearing Threshold		
	Normal	Mild deafness	Moderate deafness
<30 years old	0	5	0
30-40 years old	1	2	2
>40 years old	3	10	7
Total	4	17	9

Source: Primary Data, 2025

Table 5 shows that most respondents exposed to noise were aged >40 years, totaling 20 respondents (66.7%). Eleven respondents aged >40 years experienced mild deafness in the right ear, and 10 respondents experienced mild deafness in the left ear.

It is known that there were 6 respondents with moderate deafness in the right ear and 7

respondents with moderate deafness in the left ear who were over 40 years old and had worked at PT X for more than 10 years.

Table 6. Distribution of Hearing Loss Based on Respondents' Working Time in the Right and Left Ears

Tenure	Right Hearing Threshold		
	Normal	Mild deafness	Moderate deafness
<5 years old	2	4	1
5-10 years	0	3	1
>10 years	2	11	6
Total	4	18	8

Tenure	Left Hearing Threshold		
	Normal	Mild deafness	Moderate deafness
<5 years old	2	4	1
5-10 years	0	3	1
>10 years	2	10	7
Total	4	17	8

Source: Primary Data, 2025

Table 7. Spearman Correlation Test Results between Work Factors and Worker Hearing Threshold Values

Spearman Rank Correlation	p-value	
	Right ear	Skin ear
The relationship between noise intensity and hearing threshold values	0.801	0.832
Relationship of age to hearing threshold values	0.110	0.024
Relationship of service time to Hearing Threshold Value	0.319	0.029

Source: Primary Data, 2025

Table 7 shows the results of the Spearman Rank correlation test between noise intensity, age, and length of service with the right ear hearing threshold value, which obtained a significance value ($p > 0.05$). This means that there is no significant relationship between age, length of service, and noise intensity with the hearing threshold value of the left ear. Meanwhile, the results of the Spearman Rank correlation test between age and length of service with the hearing threshold value obtained a significance value of $p < 0.05$, which means that age and length of service



have a significant relationship with the hearing threshold value of the left ear.

DISCUSSION

Data interpretation shows that most workers at PT X experienced a decrease in Hearing Threshold Values (HTW), both in the mild and moderate deafness categories. This condition reflects a serious occupational health problem and indicates a pattern of hearing impairment consistent with Noise Induced Hearing Loss (NIHL) or hearing impairment due to noise. Exposure to high-intensity noise for long periods of time can damage the hair cells in the cochlea of the ear, leading to permanent sensorineural hearing loss.²² This phenomenon is most likely caused by extreme industrial noise exposure at PT X, where most work areas, including the Ring Line C Room, have noise levels that exceed the Threshold Limit Value. The severity of hearing damage depends on a combination of intensity (level) and duration (time) of exposure. This study did not consider other factors that could potentially affect hearing function, such as exposure to ototoxic substances or a history of ear disease among workers.

The Spearman correlation results show that age has a significant relationship with the Left Ear Hearing Threshold ($p\text{-value } 0.024 < 0.05$), although it is not significant in the right ear ($p\text{-value } 0.110 > 0.05$). These findings indicate that the older the worker, the greater the tendency for hearing function to decline, especially in the left ear.

The more dominant decline in Hearing Threshold Values (HTVs) in the left ear is related to asymmetric noise exposure in the work

environment. The difference in exposure levels between the left and right ears may be due to the position of workers relative to the main noise source, where the left ear is closer and more frequently exposed to high-intensity sounds. This phenomenon is in line with the concept of the head shadow effect, whereby the head acts as an acoustic barrier that causes differences in sound intensity levels between the two ears. The ear on the opposite side of the sound source receives a signal with a better signal-to-noise ratio than the ear on the side of the source due to the attenuation of sound energy by the head.²³

The decrease in hearing threshold in the research sample, which was dominated by workers aged >40 years and with >10 years of service, was likely influenced by a combination of physiological aging (presbycusis)²⁴ and hearing loss due to exposure to noise in the workplace.²⁵ Hearing loss usually begins to occur when a person reaches the age of 40 or older.²⁶ The older the worker, i.e., >40 years old, the 0.505 times greater the risk of hearing loss compared to workers younger than 40 years old.²⁷

The data from the respondents in this study show that most workers have worked for more than 10 years (63.3%). Statistical analysis shows a significant relationship between length of service and a decrease in hearing threshold, particularly in the left ear ($p=0.029$), but not in the right ear. This difference is likely due to asymmetric noise exposure in the work environment, where the left ear is more often directly exposed to noise sources than the right ear. This is in line with the concept of the head shadow effect, which is a phenomenon



where the head blocks some sound waves so that one ear receives higher noise intensity.²³

The length of service reflects the total cumulative noise dose received by the worker's ears during the exposure period.²⁸ Continuous noise exposure can affect hearing function because the ear has a tympanic reflex that protects the hearing receptors from excessive sound stimulation.²⁹

A person begins to experience changes in hearing after working for 5 years or more in a noisy workplace. Even prolonged exposure to noise for more than 10 years causes Noise Induced Hearing Loss (NIHL), especially when exposure occurs in an environment with high noise levels and without the use of optimal personal protective equipment.³⁰

CONCLUSIONS AND SUGGESTIONS

This study concludes that there is a significant relationship between age and length of service and a decrease in the hearing threshold of the left ear, while noise intensity does not show a significant relationship with hearing loss. Recommendations to company management include paying closer attention to the rotation of workers who have been employed for more than 10 years, transferring them to areas with noise levels below the NAB, paying attention to machine maintenance, and conducting routine health checks such as blood pressure and audiometry tests for employees.

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CONFLICT OF INTEREST

The authors hereby declare that there are no conflicts of interest in the publication of this manuscript, whether financial, non-financial, or personal, that could influence the published research results. The research data are primary data and purely the results of independent research.

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