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ORIGINAL ARTICLE

The Effect of Using Earmuffs on Hearing Loss Complaints and Subjective Stress: A Quasi-Experimental Study among Weaving Workers in Surakarta, Indonesia

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ABSTRACT

Introduction: Noise pollution from machine operations is one of industry's long-standing issues, especially in the textile manufacturing industry. High noise levels produced by weaving machine operation can harm employees' health, most notably hearing loss and stress at work. Since 1975, IT Co. Ltd., one of the biggest textile corporations in Surakarta, Indonesia, has struggled to find a solution to the issue of excessive noise, particularly in the weaving manufacturing facility. This study aims to determine the effect of employing earmuffs as a type of intervention to alleviate hearing loss complaints and subjective stress on weaving workers who are exposed to high-intensity noise. **Methods:** A time series design was used in this quasi-experimental study. This study's participants were divided into 2 groups. The first group was weaving workers who used earmuffs as ear protection (Intervention Group), and the second group did not use earmuffs (Control Group). Data collection was carried out for 6 working days to see whether there was a significant effect of using earmuffs on hearing loss complaints and subjective stress. **Results:** From the second to the sixth day, using earmuffs as ear protection did not significantly reduce hearing loss complaints. However, it showed significant findings that increased the average score of subjective stress. **Conclusion:** Using earmuffs should protect the ears from noise exposure and its effects on workers' health. However, it has been shown that using earmuffs can increase the average score of hearing loss complaints and subjective stress.

Keywords: ear protection, hearing loss, stress, weaving

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INTRODUCTION

One sector of the global economy where production carries a significant degree of environmental risk is the textile sector (da Silva *et al*., 2021). Noise pollution from weaving machine operations is one of the industry's long-standing issues (Mahapatra and Satapathy, 2024). These machines' operations produce noise levels that are over the threshold, which has a variety of detrimental consequences on employees' health, both non-auditory and auditory (Olubwa, 2021; Balážiková, Pačaiová and Tomašková, 2023).

Auditory impact is defined as a decline in human hearing ability, which can result in temporary or permanent hearing loss (Sheppard *et al*., 2020). Continuous exposure to noise levels above 85 decibels is the primary cause of hearing loss in industrial workers (Demirtaş, Saygun and Bayar Muluk, 2022), resulting in hearing loss owing to the loss of the ability of hair sensory cells in the cochlea to regenerate (Hinton *et al*., 2021). Four hundred

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sixty-six million people worldwide have a functional disability in their hearing. Workplace noise causes approximately 16% of hearing loss in adults (Zaw *et al*., 2020)

A systematic review conducted in Europe and Asia stated that the non-auditory effects of noise can cause various health problems, such as sleep disorders, cardiovascular disease, childbirth and reproduction, mental health, well-being and quality of life (Clark, Crumpler and Notley, 2020; ,Rabiei *et al*., 2021). Studies in China have shown that noise levels exceeding 85 dB can cause physiological and mental disorders. The risk increases if the noise levels exceed 95 dB (Chen *et al*., 2021).

Recent studies indicate that exposure to noise can increase the chance of workers having occupational stress disorders. Noise exposure through the sense of hearing causes central and autonomic nervous system problems. This illness generates functional responses in the sympathetic and parasympathetic nerves, resulting in a maladaptive situation that causes stress symptoms, including psychological, physiological, and behavioral problems (Sumardiyono *et al*., 2019; Setyawan *et al*., 2022). The prevalence of work-related stress among textile workers varies among developing countries. In India it is 25%, in Thailand it is 27.5%, in Iran it is 21.3%, and in Congo it is 28%. Furthermore, among Indonesian textile weaving workers, the prevalence of stress varies by city, ranging from 56.6% to 84.2% (Gobie, Ergetie and Ali, 2020; Suryani, Muliawan and Adiputra, 2020; Parmawati and Nugraheni, 2023)

The negative impact of noise has prompted various studies on noise reduction in the workplace (Bagaskara, Rachmat and Disrinama, 2022; Hidayat, Aswin and Syukri, 2024). One of the hierarchies in noise management is the use of ear protection, such as earplugs or earmuffs. Several studies have found that utilizing hearing protection devices can lessen workers' exposure to noise high-level of noise (Dastpaak *et al*., 2019; Gong *et al*., 2021) However, studies on whether using earmuffs can considerably reduce complaints of hearing loss and work stress are difficult to come by.

IT Co. Ltd., one of the largest textile corporations in Surakarta, Indonesia, has been struggling since 1975 to find a solution to excessive noise, which reached 113 dB in the weaving manufacturing facility. In this company health records, the two biggest health problems caused by noise are hearing loss and work-related stress, particularly among weaving workers. It is also observed that the company has not provided sufficient hearing protection equipment to its employees. Thus, it is interesting to investigate the impact of using hearing protection equipment (earmuffs) in reducing these complaints. This study aims to determine the effect of employing earmuffs as a type of intervention to alleviate hearing loss complaints and subjective stress on weaving workers who are exposed to high-intensity noise.

METHODS

A time series design was used in this quasi-experimental study. The Research Ethics Committee granted ethics approvals with Protocol ID Number 181/02/08/2023. Before taking part in this study, every participant signed an informed consent form. The study comprised 100 workers from the IT Co. Ltd. weaving sector in Surakarta, Indonesia, who met the inclusion and exclusion criteria. These criteria include being willing to be a respondent for six days of data collection, having a permanent worker in the weaving section, running a weaving machine 8 hours/day, not getting ill during data collection, working for more than two years, and earning more than the regional minimum wage. To minimize bias and ensure adherence to the study's inclusion and exclusion criteria, researchers worked with company supervisors to monitor the use of earmuffs by weaving workers during the 6-day study.

Previous studies on hearing loss and subjective stress interventions have typically only utilized one pre-test and one post-test. However, this is inadequate to fully describe the day-to-day trend of decreasing stress that may result from interventions aimed at reducing noise levels. This study provides a more comprehensive overview of decreasing hearing loss complaints and subjective stress, which may also be attributed to the trend of lowering noise intensity. Additionally, in accordance with Indonesian regulations, particularly the Minister of Manpower Regulation No. 5 of 2018, noise exposure monitoring is restricted to a maximum limit of 85 dB for a week of work, with a week of work at a company calculated as six working days.

The Intervention Group (IG) included 33 workers who used earmuffs to protect their hearing from high levels of noise intensity, while the Control Group (CG) included 67 workers who did not wear earmuffs. Except for the first day, none of the

participants wore earmuffs to observe trends before and after the intervention.

This study employs a questionnaire that was used in previous research and has been tested for validity and reliability. Hearing loss complaints were assessed using a questionnaire with 14 questions adapted from Devina *et al*.'s (2021). The questionnaire used to measure subjective stress is the Depression Anxiety Stress Scales-21 (DASS-21). This questionnaire consists of 21 items designed to assess the severity of general psychological distress and symptoms associated with depression, anxiety, and stress in adults (Kusumadewi and Wahyuningsih, 2020). The Mann-Whitney test was used with SPSS 23 to compare the average score of hearing loss complaints and subjective stress between the IG and the CG from day 1 to day 6.

RESULT

The study was conducted in IT Co. Ltd., especially in the weaving section, for six measurement days on the morning shift. Table 1 displays the age, length of service, and noise exposure tendencies of weaving workers, with average noise exposure levels reaching 103.06 dB.

Table 1. Tendency of Age, Length of Working and Noise Intensity in Weaving Workers

Variables	Mean	SD	Min	Max	N
Age	46.60	10.727	19	66	100
Length of working	24.71	10.705	1	45	
Noise intensity	103.06	1.911	100	113	

Table 2 shows the mean score of hearing loss complaints increased from the second to the sixth day after the intervention. However, according to the Mann-Whitney test results, there was no effect of wearing earmuffs on hearing loss complaints from the first to the sixth day of measurement (p-value > 0.05).

Table 3 shows the effect of intervention on subjective stress from the first day to the sixth day (p-value < 0.05). There was also an increase in subjective stress mean score during the earmuff intervention.

Based on Figure 1, the intervention on the second to sixth day had a negative trend in reducing the average score of hearing loss complaints and subjective stress compared to the first day before the intervention.

DISCUSSION

Industrial progress will increase worker safety threats as materials and equipment become more advanced. To prevent accidents and occupational disorders, it is vital to identify and control hazards in workplaces (Setyawan, 2020; Redana and Oktiarso, 2022; Nur *et al*., 2023). Noise from industrial machine operations is a dangerous factor that can disrupt workers' health, both physiologically and psychologically (Kee, Fauzan and Widia, 2019). Spinning and weaving are textile manufacturing operations that generate high-intensity noise exceeding the threshold value of 85 dB (Abbasi and Mehri, 2020). IT Co. Ltd, one of Surakarta's top textile enterprises, has noise difficulties that are affecting the health of its workers (Setyawan *et al*., 2022). Using earmuffs in the ears is an effort to reduce the amount of noise exposure to workers

Table 2. Mann-Whitney tests of hearing loss complaints pre- and post-intervention

Measurement Day	Hearing Loss Complaints						
	Mean	SD	Min	Max	Sig*	N	Mean Rank
Day-1 (pre-intervention)	22.52	2.611	16	28	0.071	100	CG = 54.14 IG = 43.11
Day-2 (post-intervention)	23.38	2.206	18	28	0.667	100	CG = 49.63 IG = 52.26
Day-3 (post-intervention)	23.51	3.180	15	45	0.590	100	CG = 49.42 IG = 52.70
Day-4 (post-intervention)	23.47	2.376	15	28	0.680	100	CG = 49.67 IG = 52.18
Day-5 (post-intervention)	23.55	2.422	15	28	0.696	100	CG = 49.72 IG = 52.09
Day-6 (post-intervention)	23.69	2.553	14	28	0.648	100	CG = 49.58 IG = 52.36

(Jahanshir Tavakolizadeh, Mojtaba Kianmehr*, Jalaloddin Tamaddon-Yalmeh, 2019).

The surprising finding in this study is that using earmuffs for hearing protection had a negative effect on hearing loss complaints and subjective stress. This can be seen from the increase in the average score pre- and post-intervention from the first to the sixth day after the intervention. In several previous studies, the use of ear protection should have a positive effect in reducing auditory and non-auditory complaints (Nurrokhmawati, Nataliningrum and Anggraeny, 2022; Putra and Lusno, 2024) .

Using earmuffs for hearing protection as part of hierarchy of control, especially to reduce high-level of noise exposure (Leung *et al*., 2022). Using earmuffs also has disadvantages because it can interfere with work activities, including disruption of communication, comfort and concentration (Yani, Wati and Hamidah, 2019). These problems may have triggered the increase in stress scores shown in this study. Systematic review studies in Europe also show different results that reducing noise exposure can significantly reduce psychological and mental health disorder (Hegewald *et al*., 2020).

Workplace stress can lead to several issues, such as higher rates of presenteeism and absenteeism, strained relationships among coworkers (Brunner *et al*., 2019; Schmidt *et al*., 2019) lower employee

Table 3. Mann-Whitney Tests of Subjective Stress Pre- and Post-Intervention

Measurement Day	Subjective Stress						
	Mean	SD	Min	Max	Sig*	N	Mean Rank
Day-1 (pre-intervention)	37.91	3.990	24	42	0.023	100	CG = 55.08 IG = 41.20
Day-2 (post-intervention)	38.62	3.455	25	42	0.045	100	CG = 54.54 IG = 42.29
Day-3 (post-intervention)	38.56	3.691	27	42	0.024	100	CG = 55.04 IG = 41.29
Day-4 (post-intervention)	38.60	3.725	26	42	0.010	100	CG = 55.66 IG = 40.03
Day-5 (post-intervention)	38.63	3.681	27	43	0.009	100	CG = 55.75 IG = 39.85
Day-6 (post-intervention)	38.98	3.396	28	44	0.006	100	CG = 55.99 IG = 39.35

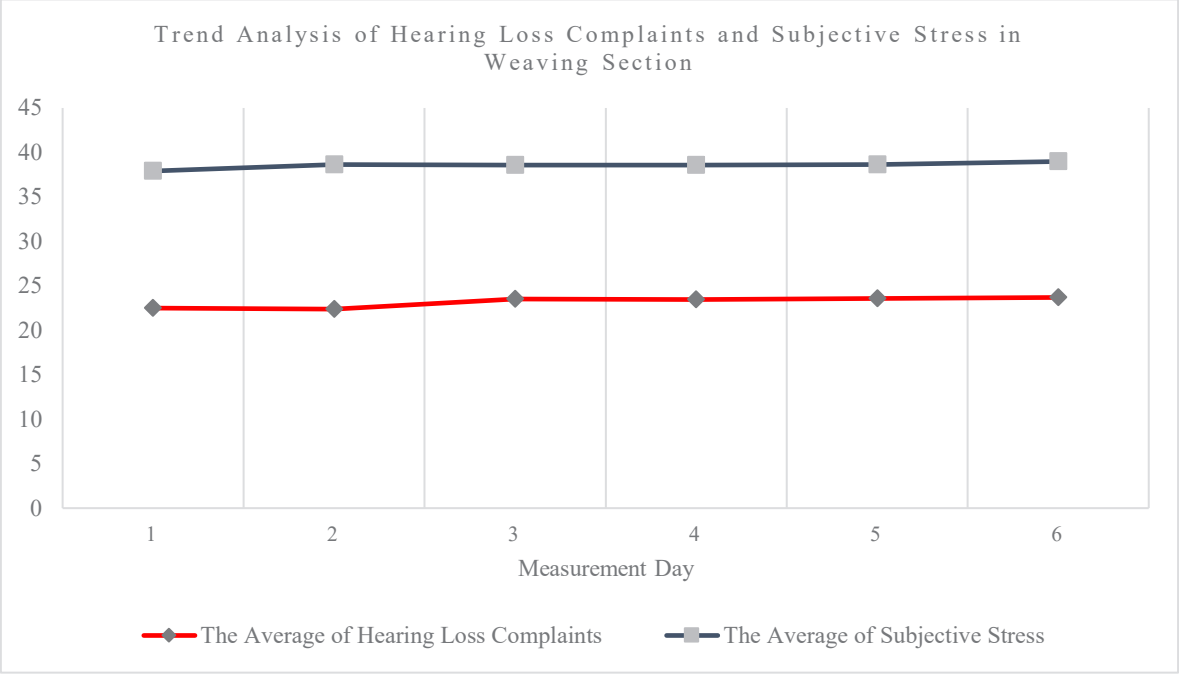

Figure 1. The Trend Analysis of Hearing Loss Complaints and Subjective Stress in Weaving Section IT Co. Ltd

motivation, lower levels of satisfaction and creativity, and higher rates of staff turnover (Al-Suraihi *et al*., 2021; Ramlawati *et al*., 2021). These issues can have a significant negative influence on productivity, direct and indirect costs, and the competitiveness of the company (Daniel, 2019; Muchiri, 2022).

Chronic high-stress levels with no corrective or adaptations increase the risk of a variety of physiological and psychological diseases (Noushad *et al*., 2021). Individuals will process pressure and stressors at the psychological level first, followed by the physiological level. Because of the cortisol hormone, these physiological changes will disturb homeostatic processes, leading the body to prepare or flee in response to threats (Chettri, Thapa and Rana, 2021; Chu *et al*., 2023).

The first effect of noise on the auditory is called the Noise Induced Temporary Threshold Shift (NITTS). Temporary hearing loss in the human ear due to reduced ability to hear soft sounds which can be caused by impulsive/sudden sounds with high intensity (Zaw *et al*., 2020). Damage can occur within hours, days to several weeks after noise exposure (Mohareb and Maassarani, 2019).

Noise Induced Permanent Threshold Shift (NIPTS) is deafness due to prolonged exposure to noise and/or greater intensity. This type of deafness is permanent and often occurs in the workplace, especially in workers who are exposed to noise above 89 dB for more than 10 years (Wardani *et al*., 2020). The appearance of NIPTS may occur suddenly or gradually. It may impact one or both ears (Sliwinska-Kowalska and Davis, 2019).

Preventing hearing loss and work-related stress is vital and should be the main objective for workers (Donovan *et al*., 2019; Themann and Masterson., 2019). Company management must provide additional measures to reduce noise exposure levels to safe and acceptable standards, ensuring the safety and comfort of workers (Saefudin and Emra, 2021).

Noise control in industry can be achieved through five stages: elimination, substitution, engineering control, administrative control, and use of personal protective equipment (Haryandi and Setiawati, 2021). The elimination control is permanent noise control with a top priority option, with the best control hierarchy, and is permanent. This control can be implemented through a program to eliminate noise sources (machines, tools, materials) whose presence exceeds the permissible threshold values (Khalik and Hermawanto, 2019). This control is the main priority in controlling risks in the workplace, but in some cases, it is considered ineffective and not practical to implement (Septio *et al*., 2020), because by changing work tools, the process/workflow in the company will change, and is very difficult to implement because changing work processes also disrupts the company's production process (Hidayat, Aswin and Syukri, 2024).

Substitution control is carried out by replacing equipment that emits high noise/exceeds the threshold value with other equipment with lower noise levels, so that noise exposure to workers is below the acceptable sound intensity/loudness value. Controlling this substitution is sometimes difficult to do, apart from requiring large costs, also because it is impossible to replace the main equipment/ materials in production activities (Moniaga and Rompis, 2019). For weaving machines that produce noise that exceeds the threshold value, replacing it with a new machine for some companies cannot be done, because it requires large funds, and the noise produced by a new loom is not necessarily below the threshold value (Septio *et al*., 2020).

Engineering controls are carried out by changing the structure of the workplace to prevent workers from being exposed to potential hazards (Fandy and Widiawan, 2022). This can be achieved through different methods, such as installing sound insulation using natural or synthetic materials, using active sound insulation, or covering sound sources (Haryandi, Setiawati and Mayasisca, 2020; Raj, Fatima and Tandon, 2020).

In the field of engineering control, both natural and synthetic fibers can be utilized to absorb noise (Arenas *et al*., 2020). Natural fibers that can be used as sound absorbers include cotton, straw, sugarcane, coconut, wood (Taiwo, Yahya and Haron, 2019; Bimara *et al*., 2021; Sastika and Febrina, 2022; Alamsyah, Maghfiroh and Ashari, 2023). The use of synthetic fibers such as rockwool can be used as a material to absorb sound waves at high frequencies (2000-7000 Hz) (Aristawati, Yulianto and Nurbaiti, 2022).

According to the Indonesian Minister of Manpower's regulations, clause 7 section 7, administrative control is the responsibility of the workforce to ensure they work safely. The regulation also specifies that workers who work eight hours per day, 40 hours a week, are only allowed to be exposed to noise levels of up to 85 dB (Wardaniyagung, 2023). In previous studies, administrative control is

a method to minimize risks and exposure to workers. This can be achieved through the implementation of system and working hour control programs. Such controls can take the form of regulating employee working and rest times, and rotating workers to different tasks (Dewi, Fathurohman and Wirati, 2023; Arifanza and Basuki, 2023; Sinaga and Nurkertamanda, 2023).

The use of personal protective equipment is an effective, but temporary control method, as it can cause discomfort during working hours (Yani, Wati and Hamidah, 2019; Setyawan, 2021). Apart from earmuffs, using earplugs also reduces exposure to noise intensity up to 30 dB.(Kwak and Han, 2021). Using these two protective devices together can reduce noise more effectively (Liu and Li, 2020; Kwak and Han, 2021).

In this study, the use of earmuffs has not been proven to be effective in protecting against the effects of noise, especially in reducing hearing loss complaints and subjective stress. Several previous studies have shown that each sound source has a different frequency, so it is also necessary to consider appropriate sound-absorbing material. The use of fibrous material has proven to be effective in reducing high-frequency noise produced by machines, compared to material made from foam in the earcups.

CONCLUSION

Using earmuffs as ear protection had a negative trend in increasing the average score of hearing loss complaints and subjective stress. This study contradicts various academicians' hypotheses. It should protect the ears from noise exposure and its effects on workers' health. Installing sound-absorbing materials in the weaving room may be a better option than employing ear protection, which can interfere with working comfort and increase the risk of work-related stress.

CONFLICT OF INTEREST

The authors declared no potential conflicts of interest with respect to the research, authorship and/or publication of this article.

AUTHOR CONTRIBUTION

HS conceived this study and performed data analysis. IQ helped design the research questionnaire. RF contributed for preparation of this manuscript. RAAR and TAEP contributed to the preparation and formatting of the paper. All authors approved the final version of the manuscript for publication.

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