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Efficacy of a Targeted Intervention Method to Improve the Use of Hearing Protection Devices among Agro-Industrial Workers in Malaysia

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Abstract: Hearing-protection devices (HPD) are crucial in protecting workers from hazardous noise exposures. Despite the mandatory implementation of hearing-conservation programmes at the workplace, compliance with proper HPD usage among workers has been shown to be poor. This study aims to develop and determine the efficacy of a targeted intervention to improve the use of HPD among noise-exposed agro-industrial workers. One group of workers was given a targeted training module, while another group received a standard training module. Their self-reported HPD use and the intention to use HPD in the future were compared to evaluate the effect of the interventions. The targeted intervention significantly increased HPD use after four months compared to the control intervention. The findings showed that improving the workers' compliance with HPD usage is possible by implementing a well-designed training method.

Keywords: targeted intervention; hearing protection devices; personal hearing protectors; agro-industrial workers

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1. Introduction

Occupational noise-exposure is a known risk factor contributing to the growing prevalence of hearing loss worldwide [1]. Unfortunately, more and more workers are exposed to hazardous levels of noise in the workplace due to the expansion of industrialisation, especially in developing countries [2,3]. In Malaysia, occupational noise-related hearing loss has consistently been the most prevalent occupational disease over the past several years [4]. Employers are required by law to protect workers from excessive noise exposure by implementing a hearing-conservation programme at the workplace. Although engineering and administrative controls are the preferred methods used to control noise hazards, they are not always practicable or adequate to eliminate all harmful noise. In such cases, personal hearing-protection devices (HPD) are still necessary to protect workers. Previous studies among Malaysian workers have generally shown poor compliance with HPD usage [5–8]. Sam et al. (2016) reported that manufacturing workers use HPD 39% of the time when exposed to high levels of noise at work [5]. A study among quarry workers showed that only 14% of them claimed to have used earplugs at the workplace, while another study in sawmills reported that only 9.6% of workers had always used earplugs while working [6,9].

Numerous interventional studies on the use of HPD among noise-exposed workers have taken a targeted or tailored approach to constructing a form of intervention [10]. A targeted intervention is an intervention developed based on the shared characteristics of members of a group [11]. In contrast, a tailored approach considers the characteristics of an individual rather than a group to devise an intervention [11]. A systematic review of

these interventions has shown that tailored interventions are more effective than targeted interventions at improving the use of HPD [10]. However, a targeted intervention can also produce desirable results while providing better value due to its cost-effectiveness compared to a tailored intervention [12]. The issue of cost and complexity in implementing an intervention is particularly relevant for industries in developing countries, more specifically for small and medium enterprises.

In a study involving factory workers, comparisons were made between three intervention groups—tailored, non-tailored, and control. It was shown that the tailored intervention contributed to a slight improvement in HPD use among the participants. As for those in the non-tailored and control group, no significant changes were detected [13]. Another study compared a computer-based tailored intervention with a control intervention. The participants' intention to use HPD in the future was assessed immediately following the intervention. The tailored group reported a greater increase in the intention to use HPD than the control group. However, at twelve months post-intervention, self-reported HPD use did not significantly differ between the groups [14]. Kerr et al. (2007) assigned construction workers to tailored and targeted intervention groups, with both groups receiving their respective interventions via interactive computer-based educational sessions. In addition to the single-session intervention, the trial included the usage of boosters. In terms of improving HPD usage among participants, the targeted method was demonstrated to be just as successful as the tailored approach. The effect of boosters on HPD usage was found to be non-statistically significant [12].

Considering the trend of industrialisation in Malaysia, there is a need for a hearing-protection training module that could boost compliance with HPD usage among agro-industrial and manufacturing workers. This study aimed to develop and determine the efficacy of a hearing-protection training module that could improve the use of HPD among these workers.

2. Materials and Methods

2.1. Study Design

This study was an interventional study involving two groups of workers who were provided with different training modules on hearing protection. At the start of the study, we gathered some baseline information about the participants. We also collected their responses to a questionnaire on the predictors of HPD use. Based on this information, we identified specific issues related to the use of HPD among the participants and subsequently developed a targeted training module for the intervention group. As for the control group, they received a generic employer-provided training module. Two outcome variables were analysed: HPD use and the intention to use HPD in the future. These variables were measured in percentages and collected at three different time points: baseline (pre-training), one-month post-training, and follow-up (four months after the training session).

The Predictors of Industrial Workers' Use of Hearing Protection Model was used as a theoretical framework for this study, as shown in Figure 1 [15]. This model was constructed based on the Predictors of Use of Hearing Protection Model by Hong et al. (2005), but with the addition of two other factors: perceived susceptibility to hearing loss and perceived severity of hearing loss [16].

2.2. Study Subjects

Two agro-processing mills were selected for this study. Both mills were owned by the same parent company and were relatively similar in size, work processes, and noise levels. The inclusion criteria for participants were workers aged 18 and above, who had been working for at least six months, stationed at hearing protection zones (areas in the mills where the noise levels reach 85 dB and above), were required to wear hearing-protection devices during working hours, and had not received any training on hearing protection within six months before the study. As part of their occupational health surveillance programme, all of the workers in both mills had undergone audiometric tests in the previous

year. Workers who had previously been diagnosed with hearing-related medical conditions were excluded from the study. Thirty workers from each mill agreed to participate, resulting in a total of sixty participants. Workers from one mill were designated as the control group, while those from another mill were designated as the intervention group.

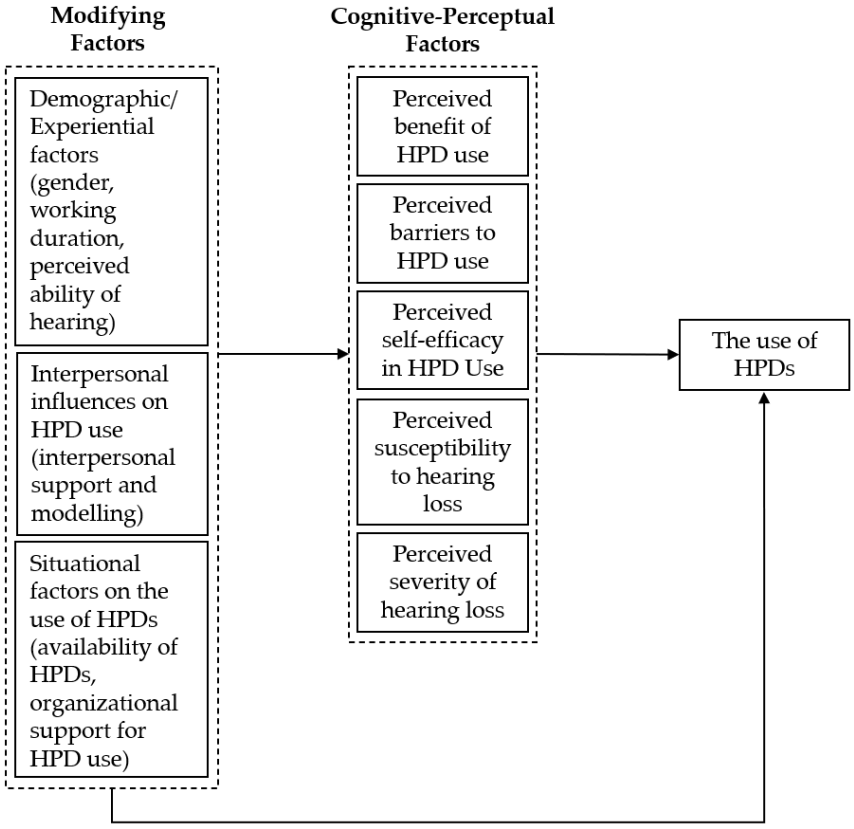

Figure 1. Predictors of Industrial Workers' Use of Hearing Protection Model (Tantranont and Codchanak, 2017).

2.3. Research Tools

2.3.1. Sociodemographic and Perceived Hearing Questionnaire

We began by collecting the participants' sociodemographic information, including their sex, age, working duration, and education level. The participants' perceived current hearing status was measured using a four-point Likert-type scale as follows: 1 = Poor, 2 = Fair, 3 = Good, 4 = Excellent.

2.3.2. Outcome Measurements: HPD Use and the Intention to Use HPD

HPD use was measured with self-reported values. Participants were asked to report the time during which they had used HPD at work on a scale of 0% to 100% in the past three months, past one month, and past one week. The mean percentage was calculated as the HPD use for that particular time point. This method of outcome measurement was repeated at follow-up. As for the measurement of HPD use post-training (one month after training), participants were only asked to report their usage for the past one month and the past one week. We used a similar percentage scale to measure the intention to use HPD and asked the participants what percentage of time they plan to use the HPD for in the future. The same question was repeated at baseline, post-training, and follow-up. HPD use was defined as using either earplugs or earmuffs. This method of self-reporting is appropriate based on the high correlation (0.89) between self-reported use and observed use in a study by Lusk et al. (1995) [17].

2.3.3. Questionnaire on the Predictors of HPD Use

This questionnaire was adapted and translated from a validated questionnaire developed by Tantranont and Codchanak (2017) [15]. The original questionnaire was written in the Thai language and consisted of 45 items within seven domains of predictors that used a four-point Likert-type scale ranging from 1 = strongly disagree to 4 = strongly agree. The questionnaire was translated into Malay, which is the local language spoken by the participants. The total number of items was also reduced to 36, although the seven domains were preserved. The validation process was carried out before the commencement of this study, involving 202 agro-industrial workers as respondents. The domains, number of items, mean score, standard deviation, and Cronbach's alpha coefficients are summarised in Table 1. For the purpose of this study, each item was analysed individually.

Table 1. Summary statistics and internal consistency measures of the predictors of HPD use.

Domain	Number of Items	Mean	SD	Cronbach's Alpha
Benefit of HPD use	5	3.31	0.4	0.9
Barriers to HPD use	10	2.18	0.41	0.84
Self-efficacy in HPD use	5	2.7	0.44	0.79
Susceptibility to hearing loss	2	3.12	0.5	0.86
Severity of hearing loss	6	3.25	0.61	0.78
Interpersonal influences	3	3.04	0.41	0.74
Situational influences	5	3.38	0.42	0.91

HPD = Hearing protection devices.

2.3.4. Module A—Intervention Group

The intervention group received a training module (Module A) constructed using a targeted approach, taking into account the participants' sociodemographic characteristics and questionnaire responses. The different aspects of the module are described below:

(i) Settings and duration The training session was conducted in a classroom setting, accommodating thirty workers at a time. A presenter delivered the module in the form of presentation slides. The session lasted one hour.

(ii) Language and complexity of content Most of the participants only received formal education up to secondary school. Hence, the module content was written in plain and straightforward Malay, minimising unnecessary technical terms. The participants were briefed on the following topics: sound and noise, the hearing system, health effects of noise, hearing conservation programme, and noise hazard control. Diagrams and analogies were used to explain relevant concepts. None of the participants were in managerial or administrative positions. Rather, they were all stationed along the mill's production line and were constantly exposed to excessive noise during working hours. Hence, when explaining noise-hazard control, we focused on the appropriate actions at the personal level (wearing HPD) instead of elaborating on engineering and administrative control measures.

(iii) Emphasis on relevant points The participants' questionnaire responses provided insight into the factors that affected their use of HPD. The main barriers to compliance were the lack of comfort and difficulties in communicating when wearing the devices. While most of them agreed that they were susceptible to hearing loss due to their working environment, 1 in 6 participants was unaware of the irreversibility of noise-induced hearing loss. Interpersonal and situational influences did not hinder their use of HPD. Based on these responses, we fine-tuned the module content to emphasise the hazardous effects of noise on workers' health, notably the permanent nature of noise-induced hearing loss, and hence the need to use HPD at all times when working in noisy environments. We also stressed the importance of preserving any remaining hearing capability for those who had already developed hearing loss.

(iv) Noise map The mill conducts yearly noise-risk assessments as part of its hearing-conservation programme. We obtained the noise map of the mill from the latest

noise-risk assessment report and presented it in one of the slides to improve the workers' understanding of the noise hazard present at their workstations.

(v) Audiogram readings Participants were handed a copy of their latest audiometric test results during the session. As the presenter explained the audiogram interpretations, the participants could compare their audiograms with the examples shown on the slides. This method made the session more interactive for the participants.

(vi) Technique demonstration The final part of the training session included a demonstration of the correct technique for wearing HPD.

2.3.5. Module B—Control Group

The control group received a standard module (Module B) prepared by the parent company for all mills under its management. The module was delivered in a two-hour training session using presentation slides, which included two main topics: sound and noise, and hearing conservation programme. For the first topic, participants were briefed on the anatomy of the human ear, the hearing process, types of noise, common environmental noise sources, types of hearing loss, effects of noise on health, and common causes of hearing loss. A large portion of the training period focused on the hearing-conservation programme. Participants were shown presentation slides on hearing-loss statistics, laws and regulations regarding noise exposure, workplace noise-risk assessments, noise mapping, noise-hazard control, and audiometric testing. However, no specific reference to the mill's actual noise exposure levels or noise mapping was made. At the end of the session, participants were shown a short video provided by the device manufacturer on the correct technique for wearing HPD.

2.4. Data Analysis

Data analysis was performed using SPSS Version 26. Statistical significance was set at $p < 0.05$. Comparisons of means for numerical data were analysed using *t*-test. Categorical data were analysed using Chi-square or Fisher's Exact test. A two-way repeated measure ANOVA (mixed-design) was conducted to determine whether there were significant changes in HPD use and the intention to use HPD between the two training groups at three time points (baseline, post-training, and follow-up). Model assumptions of normality, homogeneity of covariance, and compound symmetry were checked.

3. Results

All the participants involved in this study were males. The ages ranged from 26 to 56, while the working durations ranged from 1 year to 35 years. There was no significant difference between the groups regarding age, working duration, education level, and perceived hearing status. The characteristics of workers involved in this study are summarised in Table 2.

Table 2. Sociodemographic characteristics and perceived hearing status of study participants.

Variables	Control (n = 30)	Intervention (n = 30)	p-Value
Age (years)	41.43 (8.67) [a]	40.2 (10.26) [a]	0.617 [b]
21–30	6	7	0.053 [c]
31–40	7	10	
41–50	12	3	
51–60	5	10	
Working duration (years)	16.07 (9.32) [a]	14.87 (10.94) [a]	0.649 [b]
1–10	9	11	0.349 [d]
11–20	9	9	
21–30	11	6	
31–40	1	4	

Table 2. *Cont.*

Variables	Control (n = 30)	Intervention (n = 30)	p-Value
Education level			
Primary school	2	2	1 [d]
Secondary school	25	26	
College/University	3	2	
Perceived hearing status			
Poor	9	5	0.494 [d]
Fair	8	10	
Good	12	12	
Excellent	1	3	

[a] Mean (SD); [b] Independent t-test; [c] Chi-square; [d] Fisher's exact test.

The workers' self-reported HPD use and intention to use HPD are shown in Table 3. Paired t-tests were performed to analyse the values recorded at two time points: baseline and follow-up. There were significant improvements in HPD use and the intention to use HPD for workers who received the targeted intervention. As for the control group, the changes were not found to be significant.

Table 3. Self-reported HPD use and intention to use HPD according to training groups.

Measures	Mean (SD)			Paired Analysis Baseline & Follow-Up
	Baseline	Post-Training	Follow-Up	p-Value
HPD use				
Intervention group	60.67 (25.63)	70.50 (25.81)	77.00 (25.13)	<0.001
Control group	58.44 (22.40)	70.33 (19.21)	60.55 (27.62)	0.675
Intention to use HPD				
Intervention group	77.33 (23.18)	82.33 (22.39)	89.33 (15.3)	0.004
Control group	78.0 (12.43)	86.33 (16.91)	83.0 (23.8)	0.247

Repeated-measures ANOVA was performed to determine the effect of time and training type on HPD use and intention to use HPD, as shown in Table 4. There was an overall significant change in the HPD use over time, and a significant interaction between training type and time. As for the intention to use HPD, there was an overall significant change over time, but there was no significant interaction between training type and time. The changes in HPD use and the intention to use HPD for both groups are visualised in Figure 2.

Table 4. Changes in HPD use and intention to use HPD according to training types—Repeated Measures ANOVA.

Measures	ANOVA	F (df)	ηp2	p-Value
		HPD use		
	Time [a]	7.14 (1.9, 110.4)	0.11	0.001 [c]
	Training type [b]	1.456 (1, 58)	0.024	0.232
	Time x Training type	4.091 (1.9, 110.4)	0.066	0.021 [c]
	Time [a]	4.668 (2, 116)	0.074	0.011
	Training type [b]	0.022 (1, 58)	<0.001	0.882
	Time x Training type	1.622 (2, 116)	0.027	0.202

Note. ANOVA = Analysis of variance; [a] Baseline, post-training, & follow-up; [b] Control & targeted intervention; [c] Huynh-Feldt correction was applied.

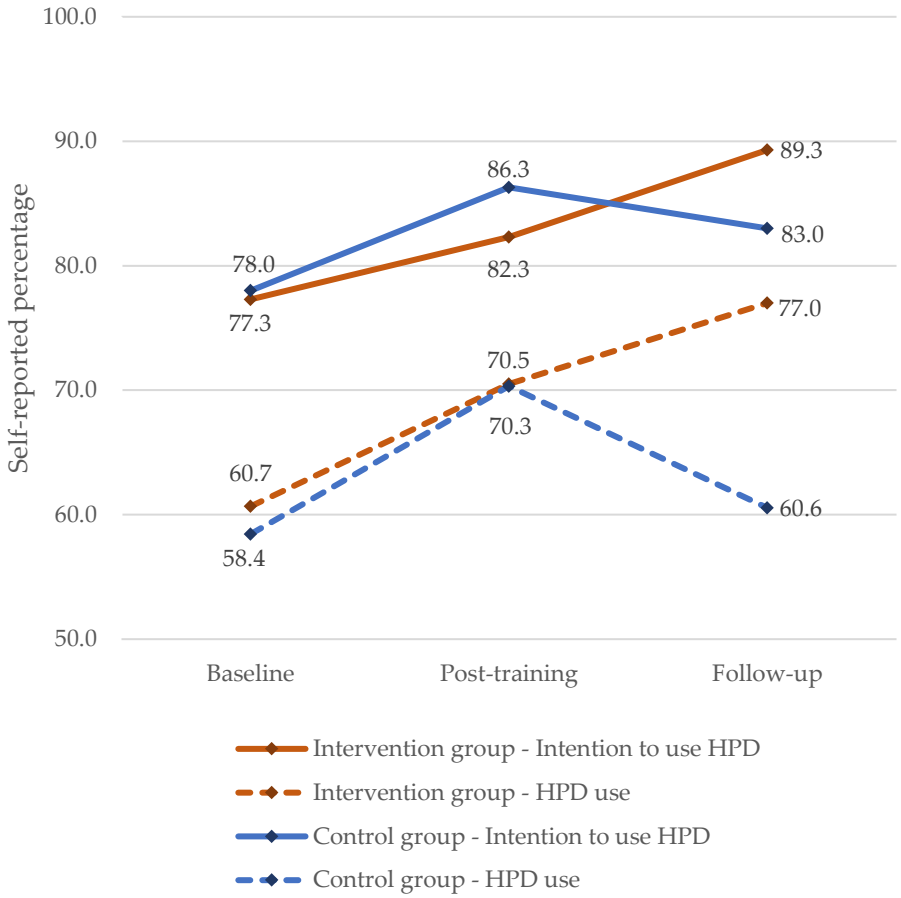

Figure 2. HPD use and intention to use HPD over time.

4. Discussion

This study exclusively involved noise-exposed mill workers who were required to be fully compliant with the use of HPD at all times during their working hours. However, our findings showed that the average baseline HPD usage among the participants was only in the region of 60%. Considering the risk of hearing damage in such a population of workers, the level of compliance was alarmingly low, albeit higher than in the findings reported in another local study among manufacturing workers, in which the average self-reported HPD use was only 38% [5]. In a survey conducted among industrial workers in Thailand, the average HPD use was higher, at 78% [15]. Another study on HPD use in America also reported relatively high baseline HPD usage, ranging between 75% and 79% [13].

Our targeted training module was shown to effectively improve the percentage of HPD use among workers in the intervention group. There was a significant increment of 10.3% from the baseline HPD use of 66.7%. This result differs from the findings reported in a study among factory workers in America, which showed no significant change in HPD use after 6 months among those who received targeted intervention and control intervention [13]. In a study involving construction workers in America, a targeted training module increased the use of HPD by 6.1% in twelve months. The same study also reported an increment of 8.3% among workers who received tailored intervention. However, the author suggested that targeted intervention provided better value when compared to tailored intervention as it was cheaper and less time-consuming [12]. The targeted intervention in our study also increased the intention to use HPD from 77.3% to 89.3%. This trend can be seen as an indication of a better level of compliance in the future.

A probable reason behind the effectiveness of the targeted module as compared to the standard module was the shorter duration of the training session. The one-hour session for the intervention group was adequate to disseminate all the main points while being

concise enough to maintain the participants' attention. Although there is no conclusive evidence to determine the typical attention span of an adult, we felt that a session exceeding an hour would leave the participants feeling fatigued and unable to concentrate on the presentation [18]. Another factor that may have contributed to the change in the participant's behaviour was the utilisation of actual audiogram results as a component of the training session. We believe that the interactive session in which workers were asked to interpret their annual audiograms significantly increased the level of awareness regarding susceptibility to hearing damage and effectively improved compliance with HPD usage in the intervention group. The positive effect of informing workers about their audiogram results on the intention to use HPD was previously suggested in another study involving construction workers [14]. Despite having accomplished our target to improve the use of HPD, the mean percentage for the intervention group only reached 77% at follow-up, which is far less than the desired 100%. Based on the participants' questionnaire responses, the main barriers to compliance were the lack of comfort and communication difficulties. Their responses were consistent with the findings of a qualitative study on HPD use among local sawmill workers. The study identified three main themes related to HPD use, namely lack of comfort, lack of awareness, and communication barriers [19]. Interestingly, another qualitative study in New Zealand on the same topic also highlighted, among others, feeling uncomfortable and communication problems as factors that hindered workers' use of HPD [20]. Notwithstanding the fact that knowledge and awareness regarding noise hazards are essential to promote HPD usage, the provision of training alone may not be adequate to address the abovementioned issues. Instead, employers would need to provide workers with other types of HPD better suited to working conditions. Another possible explanation for the low compliance is the lack of safe working habits among the workers, as most of them have been working for more than 10 years. If these workers were not compliant with HPD usage throughout their working years, they would be unlikely to change this habit after attending a single training session. We view this as a possible reason behind the results because the control group did not report any significant change in their HPD use after four months. Moreover, for those who have already sustained noise-related hearing damage, the benefit of wearing HPD may not seem to be very obvious. Nevertheless, the importance of using HPD to preserve the workers' current hearing health was emphasised during the intervention training session.

The ultimate goal of providing training for noise-exposed workers is to achieve full compliance with the use of HPD at all times when working in noisy environments. A single educational session may not be sufficient to achieve this goal. Instead, frequent training sessions or booster interventions could be beneficial in influencing workers' behaviours [12,21,22]. It is worth noting that the duration between the initial intervention and the booster intervention varies significantly across different studies, ranging from 30 days to 6 months. Hence, there is no conclusive evidence on the optimal time to administer the booster interventions. The law in Malaysia states that workers exposed to noise levels exceeding the daily noise level of 85 dB are required to attend training on personal hearing protection at least once every year. In addition, employers are also mandated to provide annual audiometric testing for these workers [23]. Therefore, we believe that our targeted intervention approach, which integrates the workers' audiometric test results into the training module, can cater to the local population of noise-exposed workers even without any specific booster intervention.

A limitation that may have influenced the results of our study was the reliance on the self-reported percentages of HPD use by the participants to measure the study outcome. This method can be too subjective and could have introduced social desirability bias into the data. However, this method was particularly useful for our research, given the constraints of the hazardous occupational environment of the mills. Furthermore, this method has been used in various studies related to HPD use [12–14,21,22,24–26]. On the contrary, observing the workers to determine HPD usage would have caused two main disadvantages, namely limiting the data to snapshot sampling and inducing the Hawthorne

effect. In addition, our findings showed that the participants' intention to use HPD in the future was consistently higher than their self-reported HPD use. The participants seemed to have reported a positive intention to use HPD while admitting to a lower level of compliance, indicating that social desirability bias did not significantly affect the outcome measurement in this study.

Overall, we managed to achieve a desirable impact on the use of HPD among the study participants using a relatively simple and low-cost approach. The contents and structure of the targeted training module used in this study could be beneficial for other industries with similar settings to promote the use of HPD among noise-exposed workers, particularly those with similar demographic backgrounds to our study participants.

5. Conclusions

This study shows the efficacy of a targeted intervention method in improving the use of HPD among noise-exposed workers. Workers who received the intervention reported an overall HPD usage of 77% at follow-up, a significant increment from 60.7% at baseline. The intention to use HPD in the future also improved significantly, from 77.3% to 89.3%. Our findings suggest that implementing a well-designed training method is practicable without the need for extensive resources. Better training on hearing protection can lead to improved compliance with HPD usage among workers, thereby reducing the health impact of workplace noise hazards.

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