Original Article

Hearing Protection Devices Use and Its Relationship with Hearing Loss among Steel Industry Workers of Samut Prakan Province, Thailand

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Objective: To investigate hearing protection devices (HPDs) use and its relationship with hearing loss among steel industry workers in Thailand.

Materials and Methods: The present cross-sectional study included 93 eligible participants who are working in the designated high-noise-level zones, which is 85 or more A-weighted decibels [dB(A)] for eight hours time-weighted average, of the two factories. Self-report forms were used to obtain HPDs use by industry workers and noise exposure level was measured with Spark® (Model 706) noise dosimeter. Audiometric screening for hearing loss was performed at a regional hospital by the qualified technician. The hearing loss in each ear was defined if the average threshold level was found to have exceeded 25 dB(A) at high frequencies of 4 and 6 kHz.

Results: The findings showed that 45.2% of workers used earplug, 16.1% used earmuff, and 38.7% used both, and most workers (55.8%) wear HDPs regularly, for six of seven days per week. Fifty seven percent of workers wear HDPs for more than 60% time of an 8-hour work shift. Most workers (75.2%) have hearing loss.

Conclusion: The authors' result revealed that almost half of workers used hearing protection devices and most workers use HPDs during the 8-hour work time. Abnormal hearing ability were found among workers. The education program such as the hazards of noise on potential auditory loss, a noise education training program and full use of HPDs are encouraged to prevent effect of noise on workers.

Keywords: Hearing protection devices, Noise induced hearing loss, Steel industry

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Noise is not only a nuisance but also a hazard to health specially to hearing. Permanent hearing loss can result from sustained exposure to hazardous noise[1]. Noise from workplaces is common and the noise level in the heavy industries tends to be higher frequency than the general work sites. The steel industry, for instance, is one of the workplaces that produces a high frequency noise from the steel-making process. Among the noise-producing machines, the workers are at higher risk of exposure to the noise while operating these machines. Therefore, it is important to ensure a safe level of noise for the workers.

One of the health problems from industrial noise is hearing loss[2]. The hearing loss occurs after years of exposure to unsafe noise, which can be irreversible. Along with the sensory-neural loss, the noise-induced hearing loss (NIHL) is associated with the loss of hair cells as a permanent threshold shift. Pathologically, it was found that a prominent loss of outer hair cells occurs at the basal turn, while a loss of inner hair cells can be limited[3]. Consequently, the degeneration of the auditory nerve occurs following the loss of the outer hair cells. The hair cell loss is influenced by many factors such as noise, ototoxic medications, or aging, resulting in an inability of mammalian sensory cells to regenerate[4]. However, such loss is preventable by avoiding excessive noise exposure and wearing hearing protection devices.

Hearing Protection Devices (HPDs) are designed to prevent a variety of noise. Specially designed and tested HPDs are essential for any workers who are working in the high-noise level zones and

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heavy industries. According to the Occupational Safety and Health Administration (OSHA), the threshold for occupational noise exposure is defined as 85 dB(A) or more. Above 85 dB(A), it is recommended that hearing conservation programs should be enlisted for workers[5]. In addition to the hearing conservation programs, effective policies for the monitoring of noise, engineered noise control systems, administrative policies of control, educational campaigns for workers, the distribution of HPDs to workers, and routine audiometric evaluations along with monitoring programs for the hearing of workers are required[6].

In Thailand, a regulation that employees on 8-hours work per day cannot be exposed to noise levels over 90 dB(A) was implemented by the Thai government in 2006. According to this regulation, an employer is required to have a specific hearing conservation policy if exposure to noise levels exceeds 85 dB(A). However, such program for workplace hearing safety was not effectively enforced until 2010[7]. Therefore, high-risk workers such as steel industry workers are provided HPDs and are also encouraged to wear them on a routine basis[8].

Despite the HPDs that protect hazards of noise and hearing loss, there are some obvious limitations associated with their use. A number of studies have shown that the use of HPDs in the factories of Thailand is as low as 20% and the use is ranging 30% to 50%[9-11]. In Samut Prakan Province, Thailand, many operating factories were built in the twentieth century during the initial period of development of factory-driven industry in Thailand. Furthermore, many workers in the province of Samut Prakan are still working in noisy factories including steel factories. As such, further assessments on the use of HPDs among steel industry workers in Thailand is required. The objectives of the present study were to investigate HPDs use among steel industry workers and to identify any relationship between HPD use and hearing loss among steel workers in the province of Samut Prakan, Thailand.

Materials and Methods

Setting

The steel industry site is the study setting, which is located in Samut Prakan Province in the central region of Thailand. It is about 30 kilometers away from the capital city, Bangkok. Samut Prakan Province is one of the provinces that have several industries. Since this province is situated at the estuary of the Chao Phraya River on the Gulf of Thailand and an important source of raw materials of county. It accommodates many workers who are working with HPDs as well as many who are not HPDs wearers.

Study design

The present study was a cross-sectional study that examined HPDs use among steel industry workers employed in high-noise-level zones of industries in Thailand, and to assess the relationship between HPD use and hearing loss. The two steel factories among the 36 industries with more than 200 workers where staff received training and hearing conservation program have already passed were selected based on their willingness to participate. Factory workers who were all working in the high noise level were included in the study. Thai male workers aged 18 to 60 years working 8-hours work per day, five days a week for at least one year with no severe or profound impairment or ear problems were selected. Ninety-three workers were recruited for the study.

Data collection

The data collection was implemented in 2016. Data collection process was available in a previous article, which was Hearing threshold levels among steel industry workers in Samut Prakan, Thailand. Briefly, the demographic characteristics were collected with pre-developed questionnaire. Regarding HPDs use, daily record of self-report of worker's HPDs wearing was obtained. The self-report and observation record of the research team supervisor on the HPDs use was checked. A high level of correlation between self-reported HPDs use and the supervisor's observation was revealed ($r=0.89$, $p<0.01$) according to a recent study[12]. For the present study, the correlation between self-reported use and the supervisor's observation was revealed ($r=0.76$, $p<0.01$). Audiometric data at frequencies of 4-, and 6-kHz was obtained from the medical records of the Samut Prakan Hospital in 2016.

The hearing loss was assessed by implementing audiometric screening at Samut Prakan hospital. The assessment was performed at least 14 hours after they had been exposed to the high levels of noise in the workplace. The hearing loss is defined when an average threshold level was found to exceed 25 dB(A) at higher frequencies of 4 and 6 kHz in each ear. All participants in the present study were assessed by the same examiner to minimize measurement errors.

For the noise exposure levels, the Spark® (Model 706) noise dosimeter was used, and the ANSI S1.4-1983, ANSI S1.25-1991, IEC 60651-1993, IEC 60804-1993, and IEC 61252-1993 standards were

strictly followed.

Data analysis

The SPSS Statistics, version 16.0 (SPSS Inc., Chicago, IL, USA) was used for data analysis. Frequencies and percentages were used for continuous data and mean values, standard deviations (SDs), and ranges were used where applicable. The use of HPDs among workers in the present study was calculated as the mean percentage time of HPDs use during the 8-hour work shift. Because the production routines were consistent, noise levels representing a typical 8-hour workday at the two factories were measured with a reliable dosimeter a single time. The recorded noise levels were calculated as the time–weighted averages of noise over 8-hour periods in units of dB(A). Associations of HPDs with hearing loss, and demographics characteristic and in relation to percentage of time HPDs were determined by using the chi-square. Associations of duration of work in steel industry and in relation to percentage of time HPDs were determined by using the independent sample t-test. A p-value of less than 0.05 (two-tailed) was statistically significant.

Ethical considerations

The ethical clearance was obtained from the Institutional Review Board for Research Involving Human Research Subjects, Health Sciences Group, Chulalongkorn University (COA: No.163/2560). Participants were fully informed about the objectives and rights to withdraw at any time of the study. All participants granted their consents by signing informed consent forms.

Results

Characteristics of study participants

The demographic characteristics of the participants and other selected variables are presented in Table 1. All participants were male who worked in designated zones at the higher noise levels of more than 85 dB(A). All participants were largely middle-aged, with a mean age of 41.67 years (SD 9.69 years, range 19 to 59 years). Over half (57.0%) of the participants were older than 40-years-old, and the majority (64.5%) of the participants finished secondary school. The length of employment of all participants varied from 1 to 39 years with a mean of 13.99 years and SD of 9.88 years. Over half (57.0%) of the participants had experienced some level of hazardous noise in the workplace over a period of 10 years or longer. The noise exposure levels of the two factories ranged from 91.79 to 96.07 dB(A). Nearly all workers (95.7%) were unaware of the noise level in their workplace. The mean working hours was found to be 59.09 hours (SD 6.42) per week.

Table 1. General characteristics of the steel industry workers (n=93)

Characteristics	Mean±SD	n (%)
Gender: male		93 (100)
Age (years) (range 19 to 59)	41.67±9.69	
≤40		40 (43.0)
>40		53 (57.0)
Highest level of education		
Primary school		21 (22.6)
Secondary school		60 (64.5)
College graduate, or higher		12 (12.9)
Length of employment (years) (range 1 to 39)	13.99±9.88	
<10		40 (43.0)
≥10		53 (57.0)
Noise exposure levels [dB(A)] at the two factories	91.79	44 (47.4)
	96.07	49 (52.6)
Worker knows information about their noise exposure level		
Yes		4 (4.3)
No		89 (95.7)
Working hours per week	59.09±6.42	

SD=standard deviation

The types of HPDs used is described in Table 2. Over (45%) of the workers routinely used earplugs. Both earplugs and earmuffs use were (38.7%), followed by earmuffs use alone (16.1%). Most participants (55.9%) were regular users of HPDs, which is six to seven days per week, often use, which is four to five days per week, sometimes use, which is two to three days per week, and once in a while, which is at least one day per week, were 12.9%, 12.9%, and 12.9% respectively. The mean percentage of time, calculated from 8-hours work shift, of using HPDs was 60.5% (SD 25.34). Based on the mean percentage of the time of HPDs used, 43% of the workers using HPDs 60% or less of the time and 57% of the workers wore HPDs more than 60% of the 8-hour work time.

Among the reasons of not wearing the HPDs, 78.5% of the workers felt that they did not work in a loud noise environment. Another most common reason was that workers experience problems when speaking with co-workers (25.8%).

To evaluate NIHL at single frequencies, the HTLs of subjects were determined based on audiometric data with low points recorded at 4 and 6 kHz. Table 3

Table 2. Use of HPDs by steel industry workers (n=93)

Details of HPD use	n (%)
Type of HPD	
Earplug (NRR 25)	42 (45.2)
Earmuff (NRR 29)	15 (16.1)
Use both earplug (NRR 25) and earmuff (NRR 29)	36 (38.7)
Frequency of HPD use	
Once in a while (at least 1 day per week)	12 (12.9)
Sometimes (2 to 3 days per week)	17 (18.3)
Often (4 to 5 days per week)	12 (12.9)
Regularly (6 to 7 days per week)	52 (55.9)
Percentage of time for which HPDs were used; mean±SD	60.54±25.34
<60	40 (43.0)
≥60	53 (57.0)
Reasons that workers reported for not using HPDs	
1. They do not think that they work in a high-noise area	73 78.5)
2. They do not think that hearing loss is related to working in loud noise	2 (2.15)
3. The industry had no the policy on use of HPDs	2 (2.15)
4. The industry had a policy regarding use of HPDs but it was not enough	2 (2.15)
5. The industry did not provide HPDs for workers	2 (2.15)
6. The industry provided an HPD for the worker but it broke	4 (4.3)
7. The industry provided an HPD for the worker but he lost it	5 (5.4)
8. HPDs were considered uncomfortable, annoying or painful to wear	5 (5.4)
9. There was a problem talking with colleagues when wearing HPDs	24 (25.8)
10. The HPDs cause allergic responses and are inconvenient to wear when working	4 (4.3)
11. They think that HPDs cannot help with hearing loss (anymore) as it had already happened	1 (1.1)
12. They think that HPDs are not necessary because they have never used HPDs before	1 (1.1)
13. They think that exposure is only for a short time, so HPD use is not necessary	9 (9.7)
14. They forgot the HPDs	7 (7.5)

HPD=hearing protection device; NRR=noise reduction rating; SD=standard deviation

Table 3. Percentage of HPDs usage among workers with normal hearing and workers with hearing loss at different frequencies (4 and 6 kHz) (n=93)

Test frequency	Percentage of HPD use by subjects			
	HTLs ≤25 dB		HTLs >25 dB	
	Mean±SD	n (%)	Mean±SD	n (%)
4 kHz				
Right ear	58.94±26.64	47 (50.5)	62.17±24.12	46 (49.5)
Left ear	56.67±27.35	33 (35.5)	62.67±24.14	60 (64.5)
Both ear				38 (40.8)
6 kHz				
Right ear	55.10±26.62	49 (52.7)	66.59±22.61	44 (47.3)
Left ear	56.17±26.50	47 (50.5)	65.00±23.55	46 (49.5)
Both ear				32 (34.4)

HPD=hearing protection device; HTLs=hearing threshold levels; SD=standard deviation

Table 4. Pearson's chi-squared test for demographics characteristic and in relation to percentage of time HPDs were utilized (n=93)

Demographics characteristic	Percentage of HPD use; n (%)		p-value (two-tailed)
	<60%	≥60%	
Age (years) (range 23 to 59)			0.047
≤40	21 (52.5)	17 (32.1)	
>40	19 (47.5)	36 (67.9)	
Education			0.042
Primary school	7 (17.5)	14 (26.4)	
Secondary school	24 (60.0)	36 (67.9)	
College graduate, or higher	9 (22.5)	3 (5.7)	
Duration of work in steel industry (years)			0.527
<10	19 (42.5)	21 (39.6)	
≥10	21 (52.5)	32 (60.4)	
Mean±SD	59.77±6.2	58.20±6.7	0.244*

HPD=hearing protection device; SD=standard deviation

* Independent sample t-test

reveals that abnormal hearing levels were recorded when an HTL cut-off point of greater than 25 dB was used. Table 3 also presents the mean and SD values with regard to the percentage of time HPDs were used for each participant category. Subsequently, HTLs of all participants were divided into two groups, with 25 dB or less HTL and more than 25 dB HTL, to determine the degree of hearing loss at 4, and 6 to form an "n×k" table for the two frequencies (4, and 6 kHz) for each ear tested. Consequently, instances of hearing loss tended to increase at higher frequencies. Over 40% of the participants of the present study experienced hearing loss at levels of 4 and 6 kHz. The mean HTLs at both frequencies for both ears of the subjects are presented in Figure 1. Additionally, Figure 1 conveys information that is supportive of the visualization of the trends across frequencies and for each ear. Figure 1 indicates that the mean HTLs values were over 60% on average, and that HTLs in the left ear had a tendency to be higher than those in the right ear.

The chi-square test results for each participant category are presented in Table 4. Subjects were

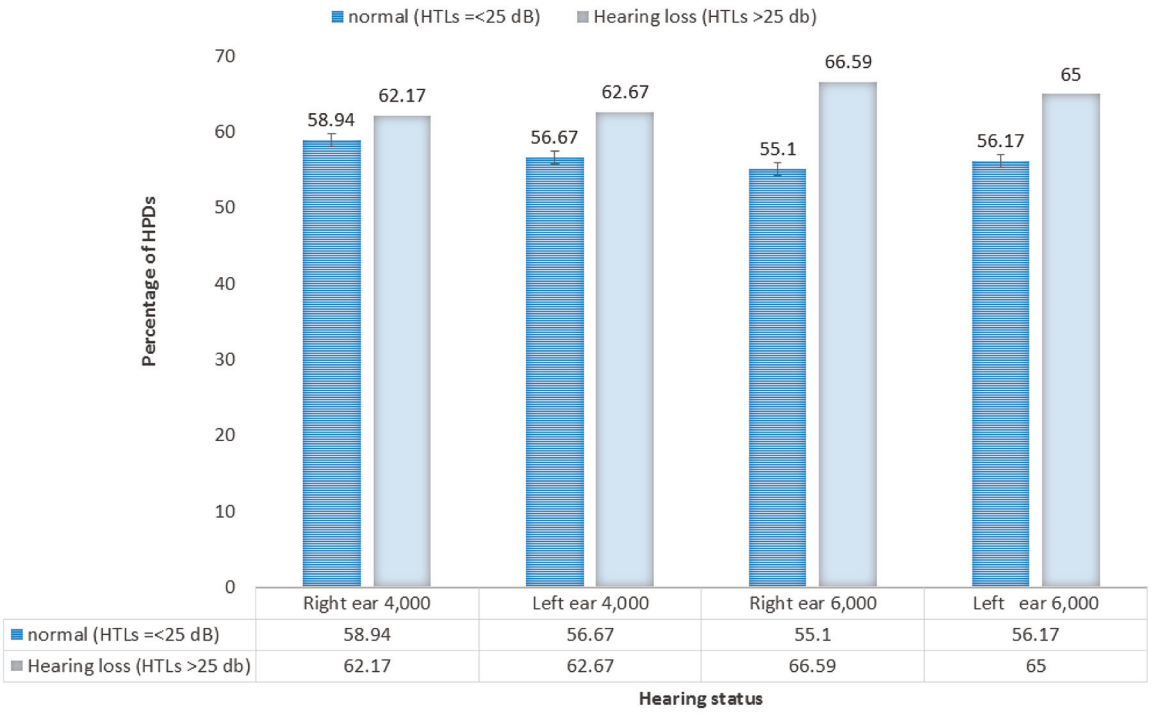

Figure 1. Mean of percentage of amount of time workers committed to wearing hearing protection devices (HPDs) with regard to different temporal frequencies in audiometry.

HTL=hearing threshold levels

Table 5. Pearson's chi-squared test for percentage of HPD use and hearing loss were utilized (n=93)

Percentage of HPD use	HPD used; n (%)			HPD used; n (%)		
	HTLs ≤25 dB (right ear)	HTLs >25 dB (right ear)	p-value (two-tailed)	HTLs ≤25 dB (left ear)	HTLs >25 dB (left loss)	p-value (two-tailed)
Status of hearing loss at 4 kHz			0.742			0.932
<60%	21 (52.5)	19 (47.5)		14 (35.5)	26 (65.0)	
≥60%	26 (49.1)	27 (50.9)		19 (35.8)	34 (64.2)	
Status of hearing loss at 6 kHz			0.100			0.243
<60%	25 (62.5)	15 (37.5)		23 (57.5)	17 (42.5)	
≥60%	24 (45.3)	29 (54.7)		24 (45.3)	29 (54.7)	

HPD=hearing protection device; HTLs=hearing threshold levels

divided into two groups based on the amount of time they used HPDs in percentages, with less than 60% and 60% or more. This was done to identify the proper use of HPDs for both groups. The chi-square test revealed associations between proper HPD use and levels of education of the subjects, and between HPD use and the age range of the participants at 40 years or younger and older than 40 years. Increased levels of education and increased in the age of the participants were associated with greater HPD use (p=0.042 and 0.047, respectively).

Table 5 shows the chi-squared test results for each participant category. The hearing loss were divided from hearing threshold level and cut point at more than 25 dB HTL. To identify the degree of hearing loss at 4 and 6 kHz and from an "n×k" table for the HPDs usage. The chi-squared tests showed no association between loss and HPDs usage at either of the test frequencies.

Discussion

The present study findings showed that

45.2%workers used earplug, 16.1% used earmuff and 38.7% used both. In addition, most workers (55.8%) wore HDPs regularly, which is six to seven days per week. Furthermore, fifty seven percent of workers wore HDPs for more than 60% time of 8-hour work. Nevertheless, most workers (75.2%) were found to have hearing loss.

In the present study, a relatively lower number of workers were found to wear hearing protection devices and nearly 56% were regular wearers of HDPs. The present study finding is higher than the study in Malaysia, in which only 5.1% of factory workers wore the protective devices for hearing protection[13]. That being said, the prevalence of hearing loss in the present study is higher. In a recent study among factories workers, the prevalence of hearing loss was 25.7% in textile factory workers[14], 47.92%, hearing loss (Grade 3) and 9.21% (Grade 4 to 5) in cotton and carpet factory workers[15], 38.8% in Darham industries workers[16], and 73.8% sensori-neural hearing loss in textile workers[17].

Hearing loss is one of health problems that could be induced by noise exposure. The longer the duration of exposure to the noise, the higher risks of hearing loss. According to a recent study, mean hearing loss was found to be 35% after 5 to 10 years, 30.64% after 11 to 15 years, and 31.39% after 16 to 20 years of exposure to the noise[18]. Even the hearing threshold levels was reported to increase from years to year of noise exposure, which was 2.34%, 8.83%, 3.39%, and 11.35%, according to a follow-up study[19]. Therefore, HPDs are essential in the workplace.

The use of HPDs are an effective method for prevention of noise-related hearing loss. HPDs use could be considered only a temporary solution because it is not always economical or practical to employ. However, HPDs may be the only available option for protection against noise exposure for many factory owners[20]. However, incorrect and incomplete understanding of the importance of HPDs is an obstacle to effectively preventing NIHL. Additionally, the absence of consistent use with regard to hearing protection when noise occurs at high levels can reduce the effectiveness of HPDs in a significant way[21,22]. Consequently, it would be necessary for personal hearing protection devices to be made available to factory workers in their workplaces. However, it is also necessary for workers to be educated on the need to regularly wear this form of equipment. Moreover, incidences of hearing loss from exposure to noise has increased of late even though the sale of HPDs have also expanded[23]. According to the published findings of a report produced by NIOSH[24], the textile industry is an important economic consideration. This is especially true with the weaving segment of the textile industry. Notably, over 87% of workers in the textile industry are routinely exposed to noise levels that exceed 80 dB[24].

The factories tested in the present study reported noise levels in a range of 91.79 to 96.07 dB(A). These results are in line with the findings of a study conducted by Chai et al[25], who assessed personal noise exposure levels in a steel cold-rolling mill. It was found that noise levels were in the range of 81 to 100 dB(A) between the sections, but the noise exposure levels of all the participant groups were found to be more than 85 dB(A). As a result, it can be concluded that steel workers in these factories were overly exposed to noise during their work shifts. Moreover, the mean number of hours worked weekly by steel workers in the present study was 59.09 (SD 6.42). This might have been a major contributing factor to the high levels of noise exposure that were recorded. Importantly, OSHA states that the noise exposure levels of workers should not exceed 90 dB(A) for eight hours of work.

When asked about the number of hours per day and the number of days per week that they were exposed to high levels of noise, a mean noise exposure level of at least eight hours a day for six days for each week was reported by the factory workers. Recent literatures indicated various reasons for not hearing HPDs. The reasons have included an inability to communicate with coworkers and the discomfort associated with wearing HPDs[26-28]. Many workers have not been motivated to consider noise at work a serious problem because hearing loss tends to occur over time. Additionally, the effects are not universal for all factory workers[28].

Several methods are commonly employed to reduce or control noise levels for workers, while the most effective method was to remove the source of the noise through engineering controls. However, the implementation of this technique can be relatively expensive and may not be feasible. The outcomes of this method may be insufficient to reduce the level of noise to an acceptable level[29]. Notably, steel processing cannot be successfully accomplished without the use of machines that generate loud noises. It is recommended that HPDs be provided to steel workers, and they should be required to use or wear them[8,30]. The present study examined the overall use of HPDs and the possible justification for not consistently wearing them in noisy workplaces.

HPDs and their use were investigated in accordance with the findings obtained from noise measurements, audiometric results, and the general perception of workers regarding noise levels, along with the hearing status of those workers. It can be determined from evaluations of HPD usage that, even though their consistent use may be necessary, the degree of frequency of HPDs usage among steel factory workers remains unsatisfactory.

An assessment of the acquired data reveals that only half of all subjects (55.9%) chose to regularly wear hearing protective devices six to seven days per week, whereas 44.1% of the subjects did not wear them with any consistency, wearing them between one and five days per week. Additionally, the mean percentage values related to the use of HPDs on routine working days was only 60.54% (SD 25.34). If the same mean cut-off point was applied when workers were divided into two groups, a majority (57%) of workers reported that they used HPDs less than average level of frequency. Notably, almost all these steel workers (95%) had no knowledge of the noise levels that they were routinely exposed to. Additionally, the most frequently given reason for choosing not to use HPDs on a consistent basis was that workers did not realize they were working in noisy environments (78.5%).

The next most common reason given was related to an inability to communicate with co-workers (25.8%), which was in accordance with the findings of previous reports[31,32]. These outcomes convey that when noise levels are measured in factories, owners should release the figures to workers to encourage the consistent use of HPDs. Companies must then consider how HPDs use affects the ability of workers to verbally communicate with each other, along with their ability to distinguish between routine communication and the sounds associated with equipment and large machines. Throughout history, the use of HPDs has always been associated with limiting the level of noise that penetrates to the workers' ears, rather than other considerations that may be just as important for HPDs to be effective[6]. The owners of the factories may be looking for a device that can provide the highest degree of attenuation, even if only minor amounts of attenuation may be needed.

When assessing the noise levels measured in the factories in the present investigation, which was up to 91 and 96 dB(A), the authors studied the noise reduction rating (NRR) of the HPDs that the factory owners offered to their workers. Those were 25 and 27 dB in laboratory tests. This led to the conclusion that many of these devices provided an excess of protection to the ears of the workers. It can therefore be determined that inadequate HPD use remains the biggest reason why HPD devices are not used effectively in noisy environments. The present study finding is in accordance with the conclusions of several other studies including a Health and Safety Executive (HSE) study from the U.K. The present study reported that one of the important factors that positively influences the frequency of HPDs use among workers was to address the negative impressions of HPDs among workers that can affect their acceptance of the devices. Negative impressions were related to discomfort and inability to communicate normally with co-workers[33,34]. It is therefore important to acknowledge that devices for hearing protection should reduce noise to acceptable levels and can also be accepted by factory workers. Consequently, it seems necessary to consider the opinions of workers regarding the selection and use of HPDs. These outcomes are consistent with the findings of other previous studies, such as a study conducted in Sistan Baluchestan Province, in Iran. In that study, it was found that 28.3% of factory workers chose not to use HPDs. Additionally, their principal reasons for choosing not to use HPDs was that they were viewed as inconvenient to use and limited their ability to communicate. They also seemed to irritate the workers by causing them to sweat and by causing their ears to itch. Notably, all these rationales could be addressed through effective training campaigns on how to use HPDs[35,36]. The current findings reveal that the defining characteristics of workers, such as age and education, are directly associated with HPDs use. Consequently, factors such as these need to be considered when evaluating HPDs use among workers in factories. These important outcomes are in accordance with the findings of other relevant studies[37,38].

Additionally, the present findings confirm that the mean HTLs of workers ranged from 29 to 40.15 dB. Notably, if a cut-off point of 25 dB was applied as an established parameter of hearing status, as normal versus abnormal, the HTLs of almost 50% of workers were found to be abnormal. As a result, the mean percentage of HPD use was found to be lower within the group of workers who possessed normal hearing status, when compared with workers in the abnormal-hearing group. This would suggest that if workers understand the relationship of HPD use to their health, they would be more likely to cooperate

with pro-active safety precautions and policies.

Another important factor that has been associated with HPDs use is the perception of the workers toward their own hearing status rather than the actual audiometric result. This could likely be a result of certain limitations that are associated with pure-tone audiometry and how information is presented on the impacts of hearing loss for an individual. If an individual perceived some form of hearing disorder, they became more apt to wear HPDs with greater consistency. This determination can be applied to policies that are dedicated to raising awareness of proper HPD use, and to specific training programs regarding the use of those HPDs. The use of HPDs among workers and their relevant perceptions regarding noise exposure and hearing loss have previously been investigated[38]. Consequently, NIOSH has recommended that the effective implementation of HPDs policies should involve various external factors[6], including characteristics of attenuation, compatibility with other available safety equipment, and improved external conditions in the workplace such as temperature, humidity, and atmospheric pressure.

The present study was limited in the way that data was obtained from two steel factories located in Thailand. Therefore, the findings cannot be generalized and applied to the workers of other factories. The present research involved a cross-sectional study and produced results that were not revealing of any definitive cause-and-effect relationship of HPD use and the health of factory workers. That may be because in the present investigation, male workers were exclusively studied.

The prevailing conditions for the present study included effective HPD-use measurement, properly applied noise exposure measurements, and informative hearing assessments. HPD use was determined through self-reporting tools, wherein workers were able to record the duration of time that they elected to use HPDs during each workday. The accuracy of the measuring process was confirmed by a qualified safety officer or supervisor and subsequently validated by the research assistants. Additionally, audiometry was used to evaluate hearing loss, and tests were conducted on Monday mornings as the first day of the work week. This was done to avoid any potential effects of temporary threshold shifts. Importantly, all audiometric tests were conducted in the same location and overseen by a single examiner.

Forms of effective noise-control strategy, such as those involving engineering and physical controls that are located near the sources of noise in factories, are not always practical and can be very difficult to put into effect. Examples of these measures include the use of suitable and standardized HPDs that employ the use of earplugs and earmuffs as one of the best alternatives. When applied correctly, these basic and affordable strategies can prevent the hearing damage of exposed workers[25-39]. Yet, the attitudes toward and the active participation of HPDs use among workers remains a vital issue. Moreover, workers should be trained to understand how to properly use HPDs[26,40].

Conclusion

Regular use of HPDs are still low among the steel industry workers and the abnormal hearing ability or hearing loss, is high enough to inform the regular HPDs use. Future research studies must focus on the need to create effective training programs regarding noise levels, and intervention programs to curb the progression of hearing thresholds should be recommended for the steel factory workers.

What is already known on this topic?

All workers (100%) working in the high noise zone must wear HPDs to help protect hearing loss.

What this study adds?

Despite participating in the HCP, approximately half the workers working in the high noise area wear HPDs less than 60% of the working time. Additionally, wearing the HPDs was not related to hearing loss. That is, the high percentage of wearers of HPDs was found in the group of workers who already have had hearing loss when compared with that of normal hearing. Education was related to wearing the HPDs.

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Authors' contributions

The authors' contribution includes conception and design, analysis, and interpretation of the data, drafting of the article, provision of study materials

and study subjects, collection and assembly of data, critical revision of the article for important intellectual content, final approval of the article, provision of study materials and subjects, and statistical expertise by Kerdonfag P, Taneepanichskul S conception and design, and interpretation of the data by Wadwongtham W.

Conflicts of interest

There are no conflicts to be declared

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