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Occupational noise exposure and hearing defects among sawmill workers in the south of Thailand

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The aim of this study was to investigate occupational noise exposure and hearing defects among sawmill workers in the south of Thailand. Seven hundred sawmill workers participated, of which 335 (47.9%) were male. The mean age of the sawmill workers was 33.5 years (*SD* 10.2), and more than 60% were <35 years old; 75.1% of the workers had less than 5 years of work experience. Only about one in four workers (25%) had been trained in use of personal protective equipment (PPE), and half of the participants never or rarely wore PPE while working. The prevalence rate of noise-induced hearing loss (NIHL) was 22.8% ($N = 42$). Male workers had significantly higher risk than female workers (odds ratio [*OR*] = 2.21). Workers aged older than 25 years had significantly higher risks for NIHL (*OR* = 3.51–12.42) than workers younger than 25 years. Sawing workers had higher risk for NIHL than office workers (*OR* = 3.07).

Keywords: occupational noise; noise-induced hearing loss; occupational health; sawmills

1. Introduction

Occupational noise is a common harmful agent and one of the most important risk factors for hearing loss in workers of different industries and ages; noise-induced hearing loss (NIHL) is responsible for approximately 16% of adult-onset hearing loss globally [1,2]. High noise levels occur in a wide range of work settings including manufacture of foods, fabrics, printed materials, metal products, drugs and watches, as well as forestry, construction and mining operations [1,3–7]. The relationship between noise and hearing loss is well understood in many industries [1,8,9], and individuals with impaired hearing often experience social isolation and depression as well as physical problems [2,10]. There are also a variety of other non-auditory health outcomes linked to noise exposure, such as injuries, hypertension and acute myocardial infarction [6,11–14].

Occupational noise exposure remains a problem in work settings and causes public health concerns. Even though noise exposure is associated with almost every work activity, some work environments are associated with particularly high noise levels [1,4,5,7]. Occupational NIHL has been a common disorder for several industries and for a significant number of compensation claims [2,4] Occupations at highest risk for NIHL include those in manufacturing, transportation, mining, construction, agriculture and the military [4,10]. In Thailand, as in many other countries, employers must comply with rules and regulations for high levels of noise exposure, which include environmental protection on human health such as the Enhancement and Conservation of National Environmental Quality Act (1992), the Factory Act (1992) and the Public Health Act (1992) [15]. However, relatively little noise exposure characterization has occurred within the sawmill industry [16], and the degree of NIHL present in workers in this industry is unknown.

Rubber wood (*Hevea brasiliensis*) timber from the rubber tree is one of the most important recycled natural resources in the wood industry. Specifically, this wood is one of the most beneficial products in the wood products industry of Thailand and accounts for approximately 75% of exported wood products [17]. Rubber wood is used to produce furniture, furniture parts and wood-based products. These exported products have made substantial contributions to Thailand's economy since 1985, accounting for approximately USD 1 billion. Properties that make rubber wood desirable include its light weight and the ease with which it can be machined and also recycled [17].

In rubber wood sawmill factories, the major process consists of six main activities: (a) logging and cutting; (b) sawing; (c) planer mill and rearranging; (d) vacuuming and wood preservation; (e) drying and plank rearranging; (f) grading, packing and storing [18]. Briefly, logs are cut to the required length and then sorted and stored in a dry area. In the cutting process, logs are cut into boards using a band saw. Next, sorted sheets are sent to a vacuum tank for preservative treatment with fungicides, mainly boric

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and borax. After impregnation, the sheets are stored to dry before shipping or further processing (which can include cutting, planer mill, laminating and sanding). Workers perform clean-up activities at the end of each shift, including use of compressed air and dry sweeping to remove wood dust.

The current study was part of a health risk assessment on occupational exposures and health hazards among Para rubber sawmills in Trang Province, southern Thailand. The objective of this study was to investigate occupational noise exposures and hearing impairments among sawmill workers. The study was undertaken in order to assess the prevalence of health hazards, to identify areas of sawmill work where noise exposure is an issue and to identify the need for implementation of specific control measures to prevent the development of NIHL.

2. Methods

2.1. Study population and settings

Invitation letters were sent to the managers of 20 factories in Trang province. The management of four factories agreed to participate in this study. Site walk-through surveys were conducted in October 2015 for a preliminary assessment and to design sampling strategies. Job safety and hazard analyses were conducted in December 2015 [18]. Questionnaires were administered to workers to collect information on demographics, smoking status, medical history, occupational background, personal protective equipment (PPE) usage status, complaints about work, risk perceptions concerning noise exposures, etc. The questionnaire format was a modification of the questionnaire survey template developed by the Ministry of Labor [19]. In addition, NIHL-related questions were included in the survey which followed the protocol of Arezes and Miguel [20].

Area noise measurements ($N = 3$) were performed to monitor noise levels in each department for sawing, planer mill and packing using a sound-level meter (NL-21; Rion, Japan). Calibration was carried out before and after each use with a Quest sound calibrator (model CA-12B; 3M, USA). Data were recorded with the NL-21 at setting 'A' (28–138 dB(A)) for 30 min as the equivalent continuous noise sound level (L_{eq}). The NL-21 was equipped with 0.5-inch incidence microphones (type 1). During measurements, the NL-21 was mounted on a tripod at a height of approximately 1.2 m.

For personal noise measurements, sawmill workers were selected randomly in each department for 44 cases, mostly in sawing ($n = 16$) and planer mill ($n = 12$), respectively. A noise integrating dosimeter (Cel320; Casella CEL, USA) was attached to the employee's belt or waistband and a small microphone (type 2) was connected to the dosimeter by a thin microphone cord, fastened to the employee's clothing on the top of the shoulder at a point midway between the ear and the outside of the shoulder. For measurements, a windscreen was placed over the microphone to reduce or eliminate wind noise, which can occur if objects bump against an unprotected microphone. This dosimeter produces a continuous reading of the percentage allowable noise dose to which the sawmill workers wearing the device have been exposed. Whenever possible the dosimeters were checked, recorded and re-set mid-sample to prevent loss of data.

An audiometry test for the participating subjects was conducted in quiet rooms in the participating facilities to ensure that the subjects were not exposed to high levels of noise during testing. The background noise levels were between 47.4 and 53.3 dB(A). Audiometry was performed using a screening audiometer (Standard No. ANSI S3.6-2004) [21]. Hearing threshold levels were measured at 500, 1000, 2000, 3000, 4000, 6000 and 8000 Hz. Binaural hearing threshold averages were calculated at the low frequencies (500 and 1000 Hz), the mid-frequencies (2000, 3000 and 4000 Hz) and the high frequencies (3000, 4000, 6000 and 8000 Hz). Hearing impairment in each of these frequency ranges was defined as average thresholds greater than 25 dB HL. In total, 20 area noise samplings (1 sampling per department for each factory) and 44 personal noise samplings (1–4 samplings per departments for each factory) were conducted.

2.2. Statistical analysis

The data analyses were conducted using SPSS version 19. Descriptive statistics were computed for all variables, including means and *SD*s as well as frequencies and percentages. Multiple logistic regression analyses were carried out to identify risk factors that contributed to NIHL.

2.3. Ethical considerations

This study was approved by the ethical committee of Chulalongkorn University Review Board (COA No. 237/2558; research project 120.1/58) and the protocol approval was from Kyoto University Review Board (ID: R0594/2016). All of the participants received a clear explanation of the study purposes and procedures, and all participants gave signed informed consent.

3. Results

Seven hundred participating workers from four factories completed questionnaire interviews. Of these participants, 335 (47.9%) were male. The mean age of the sawmill workers was 33.5 years (*SD* 10.2), and more than 60.0% of workers were <35 years old. Most workers (72.0%) had less than secondary-level education. A total of 75.1% of the workers had less than 5 years of work experience. The majority of workers (69%) had never smoked; approximately 30% of subjects were ex-smokers. Most of the workers worked in the planer mill and rearranging (39.2%)

Table 1. Descriptive characteristics of sawmill workers.

Characteristic	Factory								Total ($N = 700$)	%	p[a]
	A ($n = 198$)	%	B ($n = 273$)	%	C ($n = 130$)	%	D ($n = 99$)	%			
Gender (%) ($N = 700$)											
Male	104	52.5	113	41.1	69	53.1	49	49.5	335	47.9	0.05*
Female	94	47.5	160	58.6	61	46.9	50	50.5	365	52.1	–
Total	198	100.0	273	100.0	130	100.0	99	100.0	700	100.0	–
Age (years) ($n = 685$)											
<25	48	24.2	83	30.4	30	23.4	12	14.0	173	25.3	<0.01*
25–34	65	32.8	103	37.7	56	43.8	21	24.4	245	35.8	–
35–44	51	25.8	62	22.7	32	25.0	34	39.5	179	26.1	–
≥45	34	17.2	25	9.2	10	7.8	19	22.1	88	12.8	–
Total	198	100.0	273	100.0	119	100.0	86	100.0	685	100.0	–
$M \pm SD$	34.90 ± 11.15	–	31.17 ± 9.72	–	32.48 ± 8.82	–	37.35 ± 9.65	–	33.51 ± 10.16	–	–
Education (grade) ($N = 700$)											
Primary (<6th)	89	44.9	78	28.6	30	23.1	36	36.4	233	33.3	<0.01*
Secondary (<12th)	65	32.8	130	47.6	43	33.1	37	37.4	274	39.1	–
Tertiary (>12th)	44	22.2	65	23.8	57	43.8	26	26.3	192	27.6	–
Total	198	100.0	273	100.0	130	100.0	99	100.0	700	100.0	–
Tenure (years) ($N = 700$)											
<1	55	27.9	107	39.2	59	45.0	25	25.3	246	35.1	<0.01*
1–4	81	41.1	122	44.7	48	36.6	29	29.3	280	40.0	–
5–9	46	23.4	27	9.9	22	16.8	29	29.3	124	17.7	–
>10	15	7.6	17	6.2	2	1.5	16	16.2	50	7.1	–
Total	198	100.0	273	100.0	130	100.0	99	100.0	700	100.0	–
Smoking (%) ($N = 212$)											
Current smoker	15	22.1	7	12.3	14	34.1	22	47.8	58	27.4	0.01*
Ex-smoker	3	4.4	1	1.8	3	7.3	1	2.2	8	3.8	–
Never	50	73.5	49	86.0	24	58.3	23	50.8	146	68.9	–
Total	68	100.0	57	100.0	41	100.0	46	100.0	212	100.0	–
Department ($N = 696$)											
Sawing	42	21.3	81	29.7	16	12.4	34	35.1	173	24.9	<0.01*
Planer mill	81	41.1	107	39.2	57	44.2	28	28.9	273	39.2	–
Wood preservative	14	7.1	11	4.0	4	3.1	3	3.1	32	4.6	–
Maintenance	15	7.6	28	10.3	14	10.9	15	15.5	72	10.3	–
Packing/storage	31	15.7	14	5.1	9	7.0	1	1.0	55	7.9	–
Office	14	7.1	32	11.7	29	22.5	16	16.5	91	13.1	–
Total	197	100.0	273	100.0	129	100.0	97	100.0	696	100.0	–
PPE training ($N = 537$)											
Yes	41	28.5	58	23.8	29	30.5	10	18.5	138	25.7	0.30
No	103	71.1	186	76.2	66	69.5	44	81.5	399	74.3	–
Total	144	100.0	244	100.0	95	100.0	54	100.0	537	100.0	–

(*continued*.)

Table 1. Continued.

Characteristic	Factory								Total ($N = 700$)	%	p^a
	A ($n = 198$)	%	B ($n = 273$)	%	C ($n = 130$)	%	D ($n = 99$)	%			
PPE use ($N = 539$)											
All the time	10	6.9	15	6.1	2	2.1	3	5.5	30	5.6	<0.01*
Frequently	7	4.9	14	5.7	21	21.9	9	16.4	51	9.5	—
Sometimes	45	31.3	86	35.2	48	50.0	13	23.6	192	35.6	—
Rarely	33	22.9	45	18.4	5	5.2	8	14.5	91	16.9	—
Never	49	34.0	84	34.4	20	20.8	22	40.0	175	32.5	—
Total	144	100.0	244	100.0	96	100.0	55	100.0	539	100.0	—

[a] χ^2 test; *Significant at $p < 0.05$.
Note: PPE = personal protective equipment.

and sawing (24.9%), respectively. Only about one-quarter of the workers (25.0%) had received training in proper use of PPE and half of them reported never or only rarely wearing PPE while working (Table 1). Significant differences between the four factories were identified in gender, age and work department distribution; education level; tenure; smoking status; and use of PPE.

Table 2 presents the health status of workers derived from their questionnaire interviews based on their previous physical examinations. From physical health examinations of sawmill workers, 94.3% of sawmill workers were physically normal ($N = 484$). However, there were significant differences among factories ($p = 0.01$). Only 7.3% of workers were diagnosed with hypertension ($n = 29$), 2.0% with diabetes or high blood sugar levels ($n = 8$) and 1.0% with having high cholesterol levels ($n = 4$). About 25.0% ($N = 128$) of sawmill workers had undergone hearing loss testing, and 12.7% ($n = 21$) had been diagnosed with NIHL. There were again significant differences among factories ($p < 0.01$). Most of the sawmill workers (81.8%, $n = 436$) had experienced occupational accidents and injuries during their work in the sawmills; these injuries ranged from minor to severe (Table 2).

A total of 184 workers underwent audiometry. The prevalence of NIHL (low frequency, high frequency or both deficits) was almost 23.0% (Table 3). NIHL was detected at high prevalence for factory D (44.4%) and factory A (27.1%).

Personal noise measurements were performed randomly for sawmill workers in each department ($N = 44$), area noise measurements were conducted in the sawing, planer mill and packing departments($n = 3$) and audiometry tests for sawmill workers by department are presented in Table 4. The highest area noise measurement was in the sawing department (92.1 dB(A) on average). Other departments were measured between 88.9 and 90.3 dB(A). Only 18.2% of personal noise measurements were below the Thai 8-h exposure limit of 85.0 dB(A). Fifty-two percent of the personal monitoring measurements were 90.0 dB(A) or higher and 81.8% was higher than 85.0 dB(A). The sawing, maintenance and planer mill workers had the highest percentage of personal monitoring measurements at 90.0 dB(A) or higher (81.3, 60.0 and 58.3%, respectively).

The results of the odds ratio (OR) for NIHL of sawmill workers are presented in Table 5. Male workers were significantly at elevated risk for NIHL (OR 2.21 times higher than that of female workers). Workers older than 25 years had significantly higher risk for NIHL than workers younger than 25 years ($OR = 9.94$,12.42 and 3.51 respectively). The workers who had worked for longer than 5 years had higher risks than workers with less than 5 years of work experience. Ex-smokers had higher risks than current smokers and non-smokers. The workers who worked in the sawing department had higher risks than those in

Table 2. Descriptive characteristics of sawmill workers on physical health examinations.

	Factory										
Characteristic	A	%	B	%	C	%	D	%	Total	%	p[a]
Physical exams test (%) ($n = 513$)											
Normal	142	29.3	232	47.9	78	16.1	32	6.6	484	94.3	0.01
Abnormal	2	6.9	12	41.4	11	37.9	4	13.8	29	5.7	–
Hypertension (%) ($n = 395$)											
Normal	134	36.6	226	61.7	2	0.5	4	1.1	336	92.7	0.92
Abnormal	11	37.9	18	62.1	0	0.0	0	0.0	29	7.3	–
Blood sugar level (%) ($n = 404$)											
Normal	143	37.0	238	61.7	3	0.8	2	0.5	386	98.0	0.89
Abnormal	2	25.0	6	75.0	0	0.0	0	0.0	8	2.0	–
Cholesterol (%) ($n = 392$)											
Normal	143	36.9	242	62.4	3	0.0	N/A	N/A	388	90.0	0.86
Abnormal	2	50.0	2	50.0	0	0.0	N/A	N/A	4	1.0	–
Accidents (%) ($n = 533$)											
Yes	116	26.6	203	46.6	71	16.3	46	10.6	436	81.8	0.49
No	29	29.9	41	42.3	20	20.6	7	7.2	97	18.2	–
NIHL test (%) ($n = 518$)											
Yes	72	56.3	24	18.8	23	18.0	9	7.0	128	24.7	<0.01*
No	73	18.7	220	56.4	64	16.4	33	8.5	390	75.3	–
NIHL (%) ($n = 165$)											
Yes	2	9.5	2	9.5	15	71.4	2	9.5	21	12.7	<0.01*
No	71	49.3	20	19.3	33	22.9	20	13.9	144	87.3	–

[a] χ^2 test; N/A = no case report; *Significant at $p < 0.05$.
Note: NIHL = noise-induced hearing loss.

Table 3. Audiometry tests of sawmill workers.

Characteristic	Factory										
	A ($n = 48$)	%	B ($n = 50$)	%	C ($n = 41$)	%	D ($n = 45$)	%	Total ($N = 184$)	%	p^a
Normal	35	72.9	44	88.0	38	92.7	25	55.6	142	77.2	<0.01*
NIHL	13	27.1	6	12.0	3	7.3	20	44.4	42	22.8	–

[a] χ^2 test; *Significant at $p < 0.05$.
Note: NIHL = noise-induced hearing loss.

any other departments. Workers who never used hearing protection devices (HPDs) had higher risks than the others.

4. Discussion

Only a few studies of noise exposure levels and associated health burdens in sawmill workers have previously been conducted worldwide from the scientific reports [9]. To our knowledge no previous study has measured personal and area noise levels in Para rubber wood sawmills in Thailand or elsewhere. The main purpose of this study was to assess occupational noise exposure and hearing impairment among sawmill workers. The results of our study demonstrate the need for further occupational noise management and efforts to minimize hazardous exposures through the implementation of noise control measures among sawmill workers.

4.1. Occupational noise exposure and hearing defects among sawmill workers

The results from this study of four Trang sawmills in the south of Thailand demonstrated that the large majority of workers in sawmills were exposed to noise above permissible exposure limits (>85.0 dB(A)). The four participating sawmills are typical of the current work conditions in at least 30 other medium-scale Trang sawmills, and we believe our results can reasonably be generalized to comparable mills elsewhere in the south of Thailand. The noise exposures and hearing defects in this study are consistent with exposures reported elsewhere. This study presented results similar to the studies of Aurajananon [22] and Koehncke et al. [23]. The highest prevalence for NIHL was detected for sawing, wood preservative and planer mill workers, respectively. This study's results are similar to those of the study by Aurajananon [22] in the north of Thailand.

The noise levels are comparable to those found in other sawmills, especially in the sawing process and planer mill [23,24]. In the present study, the results of the audiometric tests were similar to the significantly higher NIHL found in a previous study among workers in the weaving section compared to other mill workers and office workers ($p < 0.01$) [25]. In addition, cumulative noise exposure may be a reliable proxy for potential NIHL. However, hearing-loss data are necessary to quantitatively assess the effect of cumulative noise exposure on hearing.

Occupational noise hearing defects are significant and prevalent around the globe, accounting for 16% of the disabling hearing loss in adults. The effects of the exposure to occupational noise are larger for male than female workers [1]. A number of studies reported the prevalence of hearing loss as a function of age in adult populations [9,26]. Dobie [23] conducted a study of occupational noise exposure and found that this exposure probably accounts for less than 10% of NIHL in adults in the USA. Most of the hearing loss in this group is age related, although some results were from unprotected exposures above 95.0 dB(A). Davies et al. [27] analyzed occupational noise exposure among British Columbia sawmills in Canada (over 14,000 noise measurements) and found workers were exposed to average noise levels of 92.0 dB(A), and 27% of sawmill workers were found to be exposed to noise at 95.0 dB(A) or higher [23]. The risk of hypertension was positively associated with noise exposure above 85 dB(A) [8]. In addition, Kersten and Backé [14] reported that high occupational noise exposure at >95.0 dB(A) was associated with myocardial infarction.

As previous studies have pointed out, the effectiveness of HPDs is limited in many occupational environments; we believe this to also be the case for the sawmill workers assessed here. Problems regarding sizing, improper fitting and comfort of protective devices and wear times <100% substantially reduce the performance of hearing protectors [20,22,27,28]. It is crucial, therefore, that alternative methods of reducing exposure to noise in sawmills, such as reduction of noise at the source, enclosure of workers and administrative controls, be considered before resorting to hearing protection. Whereas annual hearing tests have some utility in identifying those with hearing problems, additional efforts to assess personal and area noise levels are necessary to identify and implement potential controls and ultimately prevent NIHL.

4.2. Conclusions

This study has examined noise exposure and effects in four rubber wood Trang sawmills. It is clear from the results the average personal and area noise levels are above the

Table 4. Area noise measurements, personal noise measurements and audiometry tests of sawmill workers by department.

Department	Area noise measurements* (dB(A))	Personal noise measurements (dB(A))			Total number of personal noise measurements** (N = 44)	Audiometry test					
		<85.0 (n = 8)	85.0–90.0 (n = 13)	>90.0 (n = 23)		Normal (n = 142)	%	NIHL (n = 42)	%	Total (N = 184)	%
Sawing	92.1	–	3	13	16	23	16.2	21	50.0	44	23.9
Planer mill	90.3	–	5	7	12	48	33.8	11	26.2	59	32.1
Wood preservative	ND	4	–	–	4	5	3.52	2	4.8	7	3.8
Maintenance/forklift	ND	1	1	3	5	22	15.5	2	4.8	24	13.0
Packing	88.9	–	4	–	4	19	13.4	1	2.4	20	10.9
Office	ND	3	–	–	3	25	17.6	5	11.9	30	16.3

*Area noise measurements using sound level meter, a single measurement; **Personal noise measurements using noise dosimeter.
Note: ND = not determined; NIHL = noise-induced hearing loss.

limit of exposure (85.0 dB(A)). Most sawing and planer mill workers were exposed to high noise levels. This finding was similarly consistent across the four sawmills. We estimated that more than half of the workers may be overexposed to noise. We found that 22.8% of workers tested showed signs of NIHL. While multiple factors can contribute to the occurrence of NHIL, noise is the major contributor. The information in this study can provide managers with guidance to design effective regulations and safety training on hearing protection.

Rubber sawmill workers require continued protection from noise exposure, even when wearing recommended hearing protection, promotion of workers' risk perception and removal of barriers to compliance, such as comfortable devices, no interference with verbal communication and easy access. Comprehensive hearing loss prevention programs that include noise assessments, noise controls, audiometric monitoring of workers' hearing, appropriate use of hearing protectors, worker training, recordkeeping and program evaluation are needed to effectively reduce occupational NIHL in sawmill factories in Thailand.

4.3. Limitations of the study

Our study had several limitations that warrant discussion. First, our data are based on a cross-sectional study. Increasing the number of conducted samples could be one of the strategies to explore the relations of NIHL and independent variables. In addition, follow-up audiometry and noise measurement could give a stronger correlation of noise exposure and NIHL. Second, the sample size for our personal and area noise measurements, as well as for audiometry testing of sawmill workers by department, was small, and our study is therefore likely underpowered to identify associations between occupational noise exposure and NIHL outcomes. We recommend additional studies on this topic with a larger number of participants and measurements. Nevertheless, we identified several such statistically significant risk factors for NIHL. Third, the background noise levels were detected between 47.4 and 53.3 dB(A) in each sawmill. These ambient noise levels were below the recommendations of the Occupational Safety and Health Administration (OSHA), but higher than the specification of permissible ambient noise during audiometric testing according to a well-refined and scientifically tested standard (Standard No. ANSI S3.1-1999) [21] for acceptable ambient sound pressure levels and the associated errors in threshold measurement that may lessen the results of occupational noise among sawmill workers in this study. Lastly, we used self-report from questionnaire interviews. Therefore, the results may present some recall bias. Further research is needed to explore whether it is possible to generalize the findings of NIHL for other sawmills throughout Thailand.

Table 5. Odds ratios for noise-induced hearing loss of sawmill workers.

Characteristic	NIHL	%	Total	Unadjusted *OR* [95% CI]	Adjusted *R*[a], *OR* [95% CI]
Gender ($N = 184$)					
Male	23	27.1	85	1.56 [0.78, 3.12]	2.21 [1.01, 4.86]*
Female	19	19.2	99	1	1
Age (years) ($N = 184$)					
<25	4	11.8	34	1	1
25–34	6	9.1	66	7.91 [2.32, 26.98]	9.94 [2.79, 35.45]*
35–44	13	27.7	47	10.56 [3.66, 30.14]	12.42 [4.16, 37.09]*
≥45	19	51.4	37	2.76 [1.11, 6.84]	3.51 [1.23, 8.06] *
Tenure (years) ($N = 184$)					
1–4	20	16.9	118	1	1
5–9	17	38.6	44	4.90 [3.01, 7.92]*	1.06 [0.46, 2.44]
>10	5	22.7	22	1.59 [0.87, 2.91]	0.54 [0.23, 1.28]
Smoking (%) ($N = 184$)	–	–	–	–	–
Current smoker	16	30.2	53	2.31 [1.28, 4.14]*	0.51 [0.16, 1.64]
Ex-smoker	1	14.3	8	1.69 [0.72, 29.83]	1.39 [0.11, 17.60]
Never	25	20.3	123	1	1
Department ($N = 184$)					
Sawing	21	47.7	44	3.80 [0.41, 35.28]	3.07 [0.31, 30.52]
Planer mill	11	18.6	59	0.87 [0.27, 2.79]	1.16 [0.31, 4.31]
Wood preservative	2	28.6	7	0.50 [0.07, 3.34]	0.78 [0.10, 5.86]
Maintenance/forklift	2	8.3	24	2.20 [0.39, 12.97]	2.83 [0.45, 18.05]
Packing and storage	1	5.0	20	0.22 [0.07, 0.68]	0.35 [0.10, 1.23]
Office	5	16.7	30	1	1
HPD use ($N = 158$)					
Often	6	27.3	22	0.49 [0.14, 1.65]	0.53 [0.14, 1.98]
Sometimes	22	25.9	85	0.53 [0.22, 1.31]	0.43 [0.16, 1.15]
Never	8	15.7	51	1	1

[a]Adjusted for gender and age; *Significant at $p < 0.05$.
Note: CI = confidence interval; HPD = hearing protection device; NIHL = noise-induced hearing loss; *OR* = odds ratio.

4.4. Practical implications

Our findings also have practical implications for further implementations. Our study results showed that the association of noise exposure significantly correlated with the years of exposure. One important note in these respects concerning occupational and environmental settings in Trang sawmills is implementation of occupational safety training and applying the regulations for compliance of PPE use all the time for sawmill workers.

Disclosure statement

No potential conflict of interest was reported by the authors.

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