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Factors associated with risk scores among stone mortar workers exposed to high noise levels in Lampang province, Thailand

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ABSTRACT

Noise pollution is an undesirable phenomenon that affects human health and can lead to occupational hearing loss. This study was to assess associations of risk scores from exposure to noise related to their variables from noise exposure among stone mortar workers who exposed to high noise levels during their work in Lampang, Thailand. The study was conducted between August and September 2023. Data collection involved using standardized questionnaires which were developed by researchers and used scientific instruments for noise measurement. The questionnaires contained items related to population characteristics and work information, knowledge, attitude, and practice for preventing noise exposure, noise exposure measurement, and risk scores from exposure to noise. Pearson's correlation coefficient was used to analyze data. The results showed that seven factors significantly associated with risk scores from exposure to noise while performing their work. Apparently, there were four influential variables which included height of workers, ear symptoms, working hour per day, and noise measurement as tested using multiple regression analysis. Therefore, efforts should be made to manage those variables by drafting policies and creating tools for risk prediction to control the influential variables related to risk level from exposure to noise in the working area.

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1. INTRODUCTION

Informal workers are the main labor group in Thailand. According to survey data from the National Statistical Office in 2022 [1], it was found that the employed population numbered 39.6 million, of which 20.2 million were informal workers (51.0%) and 19.4 million were formal workers (49.0%). The World Health Organization (WHO) found that worldwide hearing loss affects more than 1.5 billion people and could increase to 2.5 billion by 2050 [2]. For Thailand, there is a report on the situation of surveillance, prevention, and control of diseases and health hazards of informal workers in 2021 [3]. There is a morbidity rate of disease and health hazards from occupations, namely work injuries (197.54 per 100,000 population), the musculoskeletal system (175 per 100,000 population), and noise-induced hearing loss (NIHL): (0.71 per 100,000 population). Of these data, NIHL shows the third highest morbidity rate.

Lampang province is in northern of Thailand. This province has found many mineral resources in every area. An important mineral that currently generates income for the people of Lampang province. Lignite coal is the most found mineral. There are also various industrial minerals such as tin, wolframite, scheelite, antimony, fluorite, manganite, pyrophyllite, phosphate, calcite, feldspar, barite, limestone, granite, and marble [4]. Due to the presence of various minerals, there has been an industry such as makes stone mortars. Making a stone mortar begins by drilling the stone into a cylindrical shape. After that, it is brought into a stone cutting machine to cut the head and tail to the desired size. The stone is then brought into a stone drill machine to drill a hole in the middle. Next, the stone is drilled into the core of the stone mortar to make the shape of the mortar and make the base of the mortar. The last step is to put in a grinder to decorate both the inside and outside of the stone mortar to make it smooth. From these steps mentioned, it seems that in the process of stone cutting, stone drilling and grinding machines makes loud noise.

Previous studies have demonstrated the workers exposed to high noise levels and NIHL. For example, a study on noise level in the stone crushing factory reported that the mean 8-hour time-weighted average (TWA) for personal noise exposure among stoneworkers was 87.0 dB(A), while environmental monitoring revealed an average noise level of 85.0 dB(A). The findings indicated that workers exhibited elevated hearing thresholds, particularly at high-frequency ranges, suggesting the early onset of NIHL [5]. There was a study of hearing loss among workers in a platinum mine found that 64.9% of workers were exposed to noise level exceeding 85 decibels (dBA) and 80.8% were diagnosed with hearing loss [6]. There was also a study of high noise level and hearing loss among the workers particularly as sand mining loaders. It was found that 69% of workers were exposed to loud noises greater than 85 decibels (dBA) and the prevalence of hearing loss was 37%. In addition, it was found that age of years and history of exposure to high noise levels were important factors in leading to hearing loss [7]. There was also a study of hearing loss caused by exposure to high noise levels among automotive parts workers. This study found that factors that increase the risk of hearing loss were exposed to noise over 90 decibels (dBA), smoking, and periods of working exposed to high noise levels [8]. The study was conducted on the exposure to noise of stone processing workers in northern Thailand. The results of the study found that 36.2% of the workers' exposure to noise exceeded 85 decibels (dBA). This study indicated that the job positions were important for exposure to high noise levels [9]. In addition, a study of factors affecting hearing loss among coal workers revealed that age of years, work experience, and peak noise levels were important variables in leading to hearing loss [10].

All the above research focuses on factors affecting hearing loss among workers who exposed high noise levels. However, a few studies have been implemented to identify influential factors with risk scores from exposure to high noise levels. It is clearly seen that the above refers are lacking. This is an important consideration to ensure the safety of workers, especially informal workers such as stone mortar workers who are not protected by labor protection laws of Thailand. Therefore, this study aimed to assess associations of risk scores from exposure to noise related to their variables among stone mortar workers who exposed to high noise levels during their work in Lampang, Thailand. This finding provides the crucial data based on health risk assessment and related factors from exposure to high noise levels to assist in proper preventing actions and controlling strategies.

2. METHOD

The study area was selected in Pichai sub-district, Mueang district, Lampang province in northern of Thailand, as shown in Figure 1. This location maintains an abundance of stone and various stone carvings such as stone mortar and pestle. The lifecycle of the stone mortar processes is shown in Figure 2; data collection was distributed between informal workers in the individual work functions.

A cross-sectional study was conducted from August and September 2023. The study was carried out among stone mortar informal workers who were exposed to high noise levels during their work. The total of 163 participants between 18 to 60 years of age were selected. According to a survey conducted by the researcher, the total number of informal workers engaged in stone mortar production in the studied areas of Lampang province was estimated to be 163 people. The recruitment process was based on the inclusion and exclusion criteria. These inclusion and exclusion criteria for the study are shown in Table 1. All participants must have a negative result for COVID-19 with a screening antigen test kit prior to interview and noise measurement.

Standardized questionnaires were completed by face-to-face interviews with all participants. Demographic characteristics and work information, basic health information, health behavior data, and prevention as well as control of hearing loss from exposure to high noise levels, were assessed via questionnaires. The questionnaires were developed by researchers which was approved by 3 experts before data collection with IOC; 0.70-1.00. Cronbach's alpha coefficient was used for reliability analysis regarding knowledge, attitude, and practice for surveillance, prevention, and control of hearing loss from exposure to high noise levels which was 0.7. If Cronbach's alpha coefficient 0.7 or higher was an acceptable reliability [11].

The noise level in the workplace was measured by sound level meter (SVAN 973, Svantek, Poland) and personal noise dosimeter (SV 104, Svantek, Poland) over a period of 6 hours. These instruments were approved with standard IEC 61252, ANSI/ASA S1.25, IEC 61672 class 2 and IEC 61672, ANSI/ASA S1.25 class 2, respectively. Before sampling both instruments were calibrated. The instruments were placed the calibrator firmly over the microphone housing. Switch on the calibrator and allow the 114 dB(A) level to stabilize. This should be indicated on the display at around 114 dB(A). After about 10 seconds the dosimeter automatically detects the steady signal. After noise samplings were completed, questionnaires were collected and analyzed.

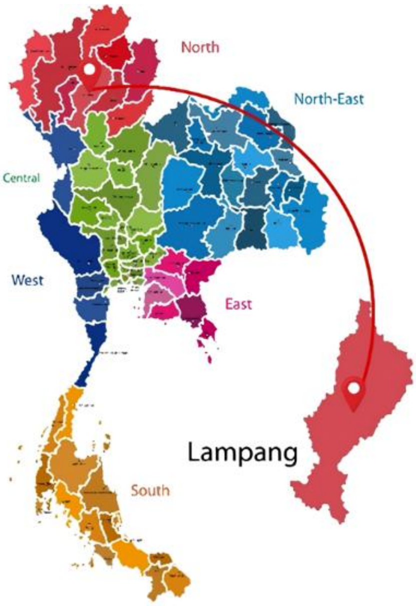

Figure 1. Lampang province map of Thailand

Figure 2. The stone mortar lifecycle processes and five job functions

Table 1. Inclusion and exclusion criteria for a cross-sectional study of stone mortar informal workers

Inclusion criteria	Exclusion criteria
Over 18 years of age	Diagnosis of hearing loss or any other related ears
Stone mortar informal workers who worked in the stone mortar lifecycle processes and five job functions more than one year in Lampang province	Having a surgery or an accident on the head or ears that affected hearing
Thai nationality and able to speak Thai language	Refusal to give informed consent

The data were analyzed with the statistical program (Statistical Package for Social Sciences: SPSS version 23). Descriptive statistics were used for analyzing the data. In addition, data related to work and noise exposure levels in the workplace were used to analyze the risk scores. The noise exposure-related risk score was applied according to Chaiyadej and Ketsakorn's study approach [12]. This standard used the parameters which included potential hazard rating as shown in Table 2, frequency rating (Table 3), health effect rating (Table 4), and noise exposure rating (Table 5) for calculation of risk scores from exposure to noise levels as presented in Table 6. Although the calculation of risk scores for noise exposure is not standardized globally as it is for chemical exposure, this study adapted the chemical exposure risk assessment method for evaluating noise-related risk scores. Pearson's correlation coefficient was used to determine the association between those variables and risk scores from exposure to noise levels. Multiple regression analysis was used to identify influential factors with risk scores. Before using multiple regression analysis, several key assumptions [13] were considered: the linear correlation was confirmed between risk scores among stone mortar informal workers exposed to high noise levels and the independent variables. The use of scatter plots showed whether there was a linear correlation. There were no multivariate normality and multicollinearity. Variance inflation factor (VIF) values and homoscedasticity were tested as an assumption. A plot of standardized residuals versus predicted values showed whether points were equally distributed across all values of the independent variables. All key assumptions were passed for testing.

Table 2. Potential hazard rating

Potential hazard level	Description
1	Below 10% of OEL-TWA
2	Below 50% of OEL-TWA
3	Below 75% of OEL-TWA
4	Equivalent 75% to 100% of OEL-TWA
5	Higher 100% of OEL-TWA

Notes: OEL-TWA = Occupational exposure limit time-weighted average (OEL- TWA). It is expressed as the time-weighted average of the noise levels exposure over an eight-hour working day, for a five-day working week unless otherwise stated.

Table 3. Frequency rating

Frequency level	Frequency	Frequency of noise exposure
1	Very infrequently	Once per year
2	Infrequently	A few times a year
3	Somewhat frequently	A few times per month
4	Frequently	Continuous for between 2 and 4 hours per shift
5	Regularly	Continuous for 8 hours shift

Table 4. Health effect rating

Health effect level*	Effect	Health effect
1	None	Noise exposure at this level has no impact on health** (Average of the noise levels exposure below 10% of OEL-TWA)
2	Low	Slight health effects, not requiring treatment, no illness necessitating sick leave, no impact on work performance or cause of impairment, recoverable without medical intervention (Average of the noise levels exposure below 50% of OEL-TWA)
3	Moderate	Moderate health impact that is recoverable, may require treatment with occasional absence from work or sick leave, or may result from repeated exposure over an extended period, without life-threatening risk (Average of the noise levels exposure below 75% of OEL-TWA)
4	High	Significant long-term health impact, severe injuries, irreversible conditions, necessitating adjustments for living with illness or consequences (Average of the noise levels exposure equivalent 75% to 100% of OEL-TWA)
5	Very high	Fatality, disability, or inability to self-care due to illness (Average of the noise levels exposure higher 100% of OEL-TWA)

*Health effects classification based on an average of the noise levels exposure.
**Currently, there is no available data indicating health impacts.

Table 5. Noise exposure rating

Frequency level	Potential hazard level					Noise exposure level		
	1	2	3	4	5	Scores	Exposure	Level
1	1	2	3	4	5	1 to 5	No exposure	1
2	2	4	6	8	10	6 to 8	Low	2
3	3	6	9	12	15	9 to 15	Moderate	3
4	4	8	12	16	20	16 to 20	High	4
5	5	10	15	20	25	21 to 25	Very high	5

Table 6. Risk scores

Health effect level	Noise exposure level					Risk of noise exposure level		
	1	2	3	4	5	Scores	Meaning	Level
1	1	2	3	4	5	1 to 5	No significant	0
2	2	4	6	8	10	6 to 8	Low	1
3	3	6	9	12	15	9 to 15	Moderate	2
4	4	8	12	16	20	16 to 20	High	3
5	5	10	15	20	25	21 to 25	Very high	4

3. RESULTS AND DISCUSSION

3.1. Results

3.1.1. Demographic characteristics and work information

There were 163 participants, including 97 females and 66 males. Table 7 shows that 59.5% of the female participants were over 60 years of age, most with an elementary education level (78.6%), most of them were married (81.6%). About 24.5%, 13.5%, and 62.0% of the participants job functions were drilling, cutting and decorating, and stone carving, respectively. However, most participants (60.1%) had no other occupation before coming to this job. About 61.3% of the participants had more than 20 years of experience in this occupation and worked an average 6.2 hours a day, almost every day.

Table 7. Demographic characteristics and work information (n = 163)

Characteristics		Number	Percent
Gender	Male	66	40.5
	Female	97	59.5
Age (years old)	18-30	2	1.2
($\bar{x}\pm$SD: 38.9$\pm$12.5)	31-40	7	4.3
	41-50	12	7.4
	51-60	63	38.6
	>60	79	48.5
Marital status	Single	18	11.0
	Married	133	81.6
	Widowed or divorced	12	7.4
Education level	Illiterate	2	1.2
	Elementary school	128	78.6
	Secondary education	31	19.0
	College or above	2	1.2
Weight (kg.)	<40	3	1.8
($\bar{x}\pm$SD: 60.8$\pm$10.4)	40-50	28	17.2
	51-60	52	31.9
	61-70	60	36.8
	71-80	17	10.5
	81-90	2	1.2
	>91	1	0.6
Height (cm.) of participants	<150	36	22.1
($\bar{x}$ $\pm$ SD: 163.1$\pm$8.6)	150-160	75	46.0
	161-170	36	22.1
	171-180	14	8.6
	>180	2	1.2
Job position	Drilling	40	24.5
	Stone cutting/decorating	22	13.5
	Carved stone	101	62.0
Working hour per day (hours)	<8	116	71.2
($\bar{x}\pm$SD: 6.2$\pm$1.5; Min-Max=1.0-10.0)	8-12	47	28.8
	>12	0	0.0
Working day per week (days)	<5	31	19.0
($\bar{x}\pm$SD: 5.0$\pm$1.4; Min-Max=1.0-7.0)	5	60	36.8
	6	24	14.7
	7	48	29.5
Job experience (years)	<5	6	3.7
($\bar{x}\pm$SD: 28.0$\pm$12.4; Min-Max=1.0-50.0)	5-10	11	6.8
	11-15	6	3.7
	16-20	40	24.5
	>20	100	61.3
Job before stone carving	No	98	60.1
	Yes	65	39.9

3.1.2. Basic health information, health behavior data, and prevention as well as control of hearing loss from exposure to high noise levels

Table 8 indicates that nearly half of the participants did not receive an annual health check-up. Approximately 67.5% of the participants had normal ear examination. The health behavior data revealed that 99.4% of the participants did not go karaoke and entertainment venues. The majority did exercise (62.0%). Only 6.1% of participants reported that they used design devices to reduce noise. In addition, 13.5% of the participants had controlled the pathway by increasing the distance between noise source and workers. However, almost all the participants (55.2%) did not use personal protective equipment while performing the work. In an effort to prevent exposure to noise, participants wore earplugs (23.9%), and earmuffs (20.9%). Knowledge, attitude, and practices for surveillance, prevention, and control of hearing loss from exposure to high noise levels were considered the criteria of Bloom [14] for interpreting the results. Most participants had neutral levels of knowledge (66.9%) and attitude (58.9%) for surveillance and prevention as well as control of hearing loss from exposure to high noise levels. Also, half of the participants had low levels of practices (54.0%) for surveillance and prevention as well as control of hearing loss from exposure to high noise levels.

3.1.3. Noise exposure assessment

Table 9 shows the highest noise level at 101.69 dBA of all job positions. Time weighted average (TWA) of noise exposure level ranged from 84.39-98.26 dBA. Approximately 50% of the measurement points exceeded the Occupational Safety and Health Administration’s (OSHA) action level of 85 decibels A-weighted (dBA) as an 8-hour time-weighted average (TWA). When this threshold is reached or exceeded, employers are required to implement a hearing conservation program, which includes noise monitoring, provision of hearing protectors, baseline and annual audiometric testing, and employee training and education [15].

Table 8. Basic health information, health behavior data, and prevention and control of hearing loss from exposure to high noise levels (n = 163)

Characteristics			Number	Percent
Basic health information	Annual health checkup	Never	71	43.6
		Normal	69	42.3
		Abnormal	23	14.1
	Ear examination	Normal	110	67.5
		Abnormal	53	32.5
Health behavior data	Exercises	No	62	38.0
		Yes	101	62.0
	Have you ever been to karaoke or an entertainment venue	No	162	99.4
		Yes	1	0.6
Prevention and control of hearing loss from exposure to high noise levels	Source control	No	145	89.0
		Yes	18	11.0
	Types of source control	Design devices to reduce noise	10	6.1
		Maintenance of equipment and tools	6	3.7
		Noise partition	2	1.2
	Pathway control	No	141	86.5
		Yes	22	13.5
	Types of pathway control	Increase the distance between noise source and workers	13	8.0
		Noise compartment	9	5.5
	Personal protective equipment	Not use	90	55.2
		Use	73	44.8
	Types of personal protective equipment	Earplugs	39	23.9
		Earmuffs	34	20.9
Knowledge, attitude, and practices for surveillance and prevention as well as control of hearing loss from exposure to high noise levels	Level of knowledge ($\bar{x}\pm$SD: 6.8$\pm$1.6)	Good knowledge: 8-10 scores (81-100%)	17	10.4
		Neutral knowledge: 6-7 scores (60-80%)	109	66.9
		Less knowledge: 0-5 scores (less than 60%)	37	22.7
	Level of attitude ($\bar{x}\pm$SD: 18.9$\pm$3.6)	Concern attitude: 22.5-28 scores (81-100%)	20	12.3
		Neutral attitude: 16.8-22.4 scores (60%-80%)	96	58.9
		Not concern attitude: 0-16.7 scores (less than 60%)	47	28.8
	Level of practices ($\bar{x}\pm$SD: 5.2$\pm$1.9)	Good practices: 8-10 scores (81-100%)	4	2.4
		Neutral practices: 6-7 scores (60-80%)	71	43.6
		Less good practices: 0-5 scores (less than 60%)	88	54.0

Table 9. Noise levels in the workplace

Job position	Number of workers	Measurement points	Noise levels (dBA)			Evaluation	
			Max	Min	TWA	Pass (%)	Not pass (%)
Drilling	40	40	101.69	81.0	95.09	1 (2.5)	39 (97.5)
Stone cutting/decorating	22	22	101.69	82.0	98.26	4 (18.2)	18 (81.8)
Carved stone	101	101	101.69	64.3	84.39	79 (78.2)	22 (21.8)

Notes: TWA is a method of calculating a worker's daily exposure to noise. It is averaged to an 8-hour workday or 40-hour week, along with the average levels of exposure to the noise and the time spent in that area. Noise levels evaluation based on the action level of 85 decibels A-weighted (dBA) as an 8-hour time weighted average (TWA).

3.1.4. Association between independent variables and risk scores

Table 10 shows the association between seven variables and risk scores from exposure to high noise levels. These variables were analyzed by using Pearson's correlation coefficient. Noise levels evaluation and job position were shown the negative correlation. In addition, height (cm.) of participants, ear examination, working hour per day (hours), working day per week (days), and noise levels (dBA) indicated the positive correlation with risk scores. Enter multiple regression analysis covered seven affected variables from those analyses. Only four influential variables were tested by using enter multiple regression analysis as shown in Table 11.

Table 10. Association between independent variables and risk scores (n = 163)

Independent variables	Pearson's correlation coefficient	p-value*
Height (cm.) of participants	0.245	0.002
Ear examination	0.163	0.038
Working hour per day (hours)	0.475	<0.001
Working day per week (days)	0.260	0.001
Noise levels (dBA)	0.404	<0.001
Noise levels evaluation	-0.309	<0.001
Job position	-0.354	<0.001

*p-value <0.05

Table 11. Influential variables and risk scores (n = 163)

Factors	Unstandardized coefficients		t	p-value*
	B	Std.error		
Constant	10.255	1.637	6.267	<0.001
Height (cm.) of participants	0.029	0.010	2.864	0.005
Ear examination	0.481	0.182	2.640	0.009
Working hour per day (hours)	0.398	0.058	6.837	<0.001
Noise levels evaluation	0.679	1.390	-4.874	<0.001
R=0.614 R^2=0.377 Std.Error=1.080 F=23.598 p-value<0.001				

* p-value <0.05

3.2. Discussion

This study included 163 stone mortar informal workers in Lampang, Thailand. There were seven factors associated with risk scores from exposure to high noise levels. The enter multiple regression analysis was used to analyze data from four influential factors. These influential factors included height (cm.) of participants, ear examination, working hour per day (hours), and noise levels evaluation in the workplace. A few previous studies have reported a positive correlation between the height of participants and risk scores from exposure to high noise levels [16]. For example, sound wave moves through air, which is a medium. When passing from one medium to another from the sound source, the speed of sound changes according to the medium and temperature. Therefore, when workers were very tall, they were more exposed to noise than workers who were less tall. Also, many previous studies reported that ear examination was positively correlated with risk scores from exposure to high noise levels. For instance, a study examining the relationship between occupational noise exposure and ear abnormalities among workers found a significant correlation between elevated noise levels and the occurrence of ear-related health issues. The most reported symptoms in affected individuals included headaches, stress, difficulties in communication, tinnitus, reduced concentration, and dizziness [17]. In addition, Zaw *et al.* [18] stated that workers with a history of ear injuries were approximately 5.63 times more likely to be at risk for changes in their hearing levels from occupation than workers with no history of ear injuries. On the other hand, a study by Tambs *et al.* [19] found that workers with congenital disorders and a history of ear injuries may be at increased risk for occupationally induced changes in hearing thresholds. However, this study was not statistically significant at the 95% confidence level. Also reported that working hours per day were positively correlated with risk scores from exposure to high noise levels. For instance, individuals exposed to occupational noise for more than 8 hours per day are at an increased risk of experiencing changes in hearing levels compared to those with shorter durations of noise exposure [20]. On the other hand, there were studies that found that working hours per day (hours) and risk scores from exposure to noise levels were not significantly related at the 95% confidence level [8], [21]. Conversely, noise levels evaluation was found to be negatively correlated with risk scores from exposure to noise levels. For instance, noise exposure levels of 86-90 dBA and over 90 dBA significantly increase the risk of hearing loss in one ear at the 95% confidence level. It was also found that noise exposure levels greater than 90 dBA significantly increased the prevalence of hearing loss in both ears at the 95% confidence level [8], [22] conducted a study evaluating changes in hearing loss based on audiometric test of workers in the welding industry in 2008 and 2009 in Iran. It was found that both ears exposed to high noise levels greater than 90 dBA were approximately 2.75 to 11.55 times more at risk of hearing loss than high noise levels 85–90 dBA. Furthermore, there were many studies in relating to high noise levels and hearing loss in Thailand. For example, the relationship between exposure to noise levels in the work area and hearing loss among workers producing air conditioning parts and refrigeration equipment found that noisy working environment were significantly associated with hearing loss at the 95% confidence level [23]. There were also studies to confirm the relationship between noise levels in work areas and hearing loss, such as studies by [24]-[26]. However, there were few studies on factors related to risk scores from exposure to high noise levels. Therefore, this is the first report on influential factors of risk scores from exposure to high noise levels among stone mortar informal workers in Thailand. These findings would be very useful for preventing and controlling measures that influence factors, setting policies and strategies to mitigate the risks for stone mortar informal workers and the other exposed population. Another possible limitation in this study was relatively short, including a limited number of stone mortar informal workers and samples, and the results may therefore not be generalized across the entire stone mortar informal workers' population.

4. CONCLUSION

Working with high noise levels required important measures to reduce exposure. Measures generally included wearing a hearing protection, implementing design devices to reduce noise, noise partition, noise compartment, increasing the distance between noise source and workers, maintenance of equipment and tools, and avoiding activities that generate excessive noise levels. Regular checkups were also important to monitor their health for signs of hearing loss. Factors associated with risk scores from exposure to noise levels, especially the worker's height factor was found for the first time in this study. This influential factor relating to the risk scores from exposure to noise levels in the working area together with other factors such as ear examination, working hour per day (hours), and noise levels evaluation. Therefore, these influential factors are useful in setting proactive measures among stone mortar informal workers exposed to high noise levels. Moreover, these influential factors will also create the model and web application for screening the risk from exposure to high noise levels.

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AUTHOR CONTRIBUTIONS STATEMENT

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C : **C**onceptualization
M : **M**ethodology
So : **So**ftware
Va : **Va**lidation
Fo : **Fo**rmal analysis
I : **I**nvestigation
R : **R**esources
D : **D**ata Curation
O : Writing - **O**riginal Draft
E : Writing - Review & **E**diting
Vi : **Vi**sualization
Su : **Su**pervision
P : **P**roject administration
Fu : **Fu**nding acquisition

CONFLICT OF INTEREST STATEMENT

The authors declare no conflict of interest.

ETHICAL APPROVAL

The Human Research Ethics Committee of Thammasat University reviewed and approved the aims and procedures of this study. Registry and registration no. of the study: ethical approval no.058/2566 and the date of approval was June 19, 2023.

DATA AVAILABILITY

The data supporting the findings of this study are not available due to privacy and ethical restrictions.

REFERENCES

[1] National Statistical Office Thailand (NSO), "The informal employment survey 2022." Accessed: Dec. 20, 2022. [Online]. Available: https://www.nso.go.th/nsoweb/nso/statistical_system?set_lang=en

[2] World Health Organization (WHO), "WHO director-general's opening remarks at the launch of the world report on hearing." Accessed: Nov. 10, 2023. [Online]. Available: https://www.who.int/director-general/speeches/detail/who-director-general-s-opening-remarks-at-the-launch-of-the-world-report-on-hearing.

[3] Department of Disease Control Thailand, "Report on the situation of surveillance, prevention, and control of diseases and health hazards of informal workers in 2021 (in Thai: *รายงานสถานการณ์ การดำเนินงานเฝ้าระวัง ป้องกัน ควบคุมโรคและภัยสุขภาพจากการประกอบอาชีพ*)." Accessed: Nov. 20, 2021. [Online]. Available: https://ddc.moph.go.th/uploads/ckeditor2//files/20220224_01A.pdf.

[4] S. Yiamjanya, "Mining industrial landscape, heritage value and tourism opportunity: Focus on Lampang's Mae Moh Mine and communities in its neighborhood," *Electronic Journal of Open and Distance Innovative Learning (e-JODIL)*, vol. 10, no. 1, pp. 165–187, 2020.

[5] F. J. Huang, C. J. Hsieh, C. H. Young, S. H. Chung, C. C. Tseng, and L. M. Yiin, "The assessment of exposure to occupational noise and hearing loss for stoneworkers in Taiwan," *Noise and Health*, vol. 20, no. 95, pp. 146–151, 2018, doi: 10.4103/nah.NAH_45_17.

[6] L. Ntlhakana, G. Nelson, and K. Khoza-Shangase, "Estimating miners at risk for occupational noise-induced hearing loss: A review of data from a South African platinum mine," *South African Journal of Communication Disorders*, vol. 67, no. 2, pp. e1–e8, Mar. 2020, doi: 10.4102/sajcd.v67i2.677.

[7] D. Landen, S. Wilkins, M. Stephenson, and L. McWilliams, "Noise exposure and hearing loss among sand and gravel miners," *Journal of Occupational and Environmental Hygiene*, vol. 1, no. 8, pp. 532–541, Aug. 2004, doi: 10.1080/15459620490476503.

[8] A. Sriopas, R. S. Chapman, S. Sutammasa, and W. Siriwong, "Occupational noise-induced hearing loss in auto part factory workers in welding units in Thailand," *Journal of Occupational Health*, vol. 59, no. 1, pp. 55–62, 2017, doi: 10.1539/joh.15-0291-OA.

[9] S. K. Sayler, R. N. Long, K. Nambunmee, and R. L. Neitzel, "Respirable silica and noise exposures among stone processing workers in northern Thailand," *Journal of Occupational and Environmental Hygiene*, vol. 15, no. 2, pp. 117–124, Feb. 2018, doi: 10.1080/15459624.2017.1393080.

[10] M. Onder, B. D. Iroz, and S. Onder, "Investigation of factors affecting hearing loss of open pit coal mine employees with categorical data analyses," *Scientific Mining Journal*, vol. 61, no. 1, pp. 19–24, 2022, doi: 10.30797/madencilik.977752.

[11] C. E. Lance, M. M. Butts, and L. C. Michels, "The sources of four commonly reported cutoff criteria," *Organizational Research Methods*, vol. 9, no. 2, pp. 202–220, Apr. 2006, doi: 10.1177/1094428105284919.

[12] R. Chaiyadej and A. Ketsakorn, "Development of rapid prediction model for silicosis risk among stone carvers in Nakhon Ratchasima, Thailand," *Journal of Occupational and Environmental Hygiene*, vol. 21, no. 11, pp. 765–777, Nov. 2024, doi: 10.1080/15459624.2024.2398009.

[13] M. A. Poole and P. N. O'Farrell, "The assumptions of the linear regression model," *Transactions of the Institute of British Geographers*, no. 52, pp. 145–158, 1971, doi: 10.2307/621706.

[14] E. W. Eisner, B. S. Bloom, J. T. Hastings, and G. F. Madaus, *Handbook on formative and summative evaluation of student learning*, vol. 14, no. 1. 1972. doi: 10.2307/1319918.

[15] Occupational Safety and Health Standards (OSHA), "Occupational noise exposure (29 CFR 1910.95)," U.S. Department of Labor. Accessed: May 18, 2025. [Online]. Available: https://www.osha.gov/laws-regs/regulations/standardnumber/1910/1910.95.

[16] Technical Committee ISO/TC 43, "Acoustics. Description, measurement and assessment of environmental noise. Part 2: Determination of sound pressure levels," International Organization for Standardization (ISO). Accessed: May 18, 2025. [Online]. Available: https://www.iso.org/obp/ui/en/#iso:std:iso:1996:-2:ed-3:v1:en.

[17] M. Basner *et al.*, "Auditory and non-auditory effects of noise on health," *The Lancet*, vol. 383, no. 9925, pp. 1325–1332, Apr. 2014, doi: 10.1016/S0140-6736(13)61613-X.

[18] A. K. Zaw *et al.*, "Assessment of noise exposure and hearing loss among workers in textile mill (Thamine), Myanmar: A cross-sectional study," *Safety and Health at Work*, vol. 11, no. 2, pp. 199–206, 2020, doi: 10.1016/j.shaw.2020.04.002.

[19] K. Tambs, H. J. Hoffman, H. M. Borchgrevink, J. Holmen, and S. O. Samuelsen, "Hearing loss induced by noise, ear infections, and head injuries: results from the Nord-Trøndelag Hearing Loss Study (in Spanish: *Hipoacusia inducida por ruido, infecciones de oído y lesiones cefálicas: resultados del estudio Nord-Trøndelag sobre pérdidas)*," *International Journal of Audiology*, vol. 42, no. 2, pp. 89–105, Jan. 2003, doi: 10.3109/14992020309078340.

[20] B. Gopinath, C. McMahon, D. Tang, G. Burlutsky, and P. Mitchell, "Workplace noise exposure and the prevalence and 10-year incidence of age-related hearing loss," *PLOS ONE*, vol. 16, no. 7, p. e0255356, Jul. 2021, doi: 10.1371/journal.pone.0255356.

[21] J.-W. Park, J.-S. Park, S. Kim, M. Park, H. Choi, and S. Lim, "The association between long working hours and hearing impairment in noise unexposed workers: data from the 5th Korea National Health and Nutrition Examination Survey (KNHANES 2010–2012)," *Annals of Occupational and Environmental Medicine*, vol. 28, no. 1, p. 55, Dec. 2016, doi: 10.1186/s40557-016-0140-1.

[22] M. S. Attarchi, Z. Sadeghi, F. Dehghan, M. M. Sohrabi, and S. Mohammadi, “Assessment of hearing standard threshold shift based on audiometric findings in steel company workers,” *Iranian Red Crescent Medical Journal*, vol. 12, no. 6, pp. 644–649, 2010.
[23] K. Arjkaew, V. Pruktharathikul, and S. Chaiklieng, “Prevalence of hearing loss and noise exposure among workers in air conditioning and refrigeration components manufacturing,” *The Public Health Journal of Burapha University*, pp. 1–13, 2020.
[24] C. Poldongnok and C. P. Polyong, “Factors associated with the noise-induced hearing loss of car wash workers in Bangkhae area, Bangkok (in Thai: *ปัจจัยที่มีความสัมพันธ์กับการสูญเสียการได้ยินของพนักงาน ในสถานประกอบกิจการล้างรถในเขตบางแค กรุงเทพมหานคร*),” *The Journal of Faculty of Nursing Burapha University*, vol. 30, no. 3, pp. 98–111, 2022.
[25] P. Singhapoom, S. Lormphongs, and J. Pusapukdepob, “Combined effect of noise exposure and smoking to hearing loss among casting factory workers, Panthong District, Chon Buri Province,” *The Public health journal of Burapha University*, vol. 8, no. 2, pp. 100–108, 2014.
[26] A. T. Teskatuk, “Hearing loss in a textile factory (in Thai: *การ สูญ เสีย การ ได้ยิน ใน โรงงาน ทอ ผ้า*),” *The Journal of Faculty of Nursing Burapha University*, vol. 9, no. 3, pp. 57–58, 2022.

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