

Association between Noise Exposure and Quality of Life among People Living Near Stone-Mortar Factories, Phayao Province, Northern Thailand

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ABSTRACT

Noise may have adverse effects on health and quality of life (QoL). This study assessed the association between noise exposure and QoL among people living near stone-mortar factories. A cross-sectional descriptive study was conducted using 269 subjects. The data was collected using questionnaires, sound level meter, and a geographic information system technique. The statistical analysis was carried out using independent t-test, ANOVA, Pearson's correlation coefficient test and multiple binary logistic regression analysis. The average noise in factory no. 2, 4, and 5 was found to be higher than the standard level of NIOSH at 85 dB(A) and OSHA at 90 dB(A) for an 8-hour TWA. The multiple binary logistic regression analysis showed that an increasing residential distance was associated with high noise exposure after adjusting for age, education, income, length of stay in community, and overall QoL. The local policy makers should be required to emphasize on the reduction of noise pollution in stone-mortar factories and health surveillance of the residential neighborhood.

1. INTRODUCTION

Noise is one of the major global environmental issues, apart from being an unwanted nuisance (WHO, 2011). Moreover, exposure to high levels of noise may have adverse effects on the health and the quality of life (QoL) of not only the workers at the site but also of the people living around these noise sources (Seidman and Standing, 2010; Padungtod et al., 2011). The sources of noise pollution may be natural or artificial such as agriculture, mining, construction, transportation, and industries (Chepesiuk, 2005; WHO, 2011; Sordello et al., 2019). Approximately 16% of the world population suffers from hearing loss, ranging from 7% to 21% in the various subregions (Nelson et al., 2005). The World Health Organization (WHO) reported that the number of people affected by hearing loss was approximately over 466 million people in 2018 globally (WHO, 2018).

Against the same backdrop, many studies have found links between environmental noise and a multitude of health disorders, including cardiovascular

diseases, sleep disturbance, tinnitus, annoyance, hypertension, and hearing loss (WHO, 2011; Basner et al., 2014). The sound pressure level generated depends on factors such as human activities, type of noise source, and distance from the source to the residence (Han et al., 2015; Sordello et al., 2019). The primary cause of occupational noise-induced hearing loss (NIHL) is damage to the hair cells of the cochlea. Exposure to excessive noise can cause temporary or permanent hearing loss. Especially, the case of continuous or repeated long-term exposure to noise is extremely perilous as it can lead to permanent threshold shift (WHO, 2011; Chen et al., 2014; WHO, 2018). According to previous studies, those exposed to high noise level were found to have a significantly poorer QoL (Nitschke et al., 2014; Welch et al., 2018). QoL is a multidimensional concept comprised of physical component summary (PCS) and mental component summary (MCS). It is included in widely-used health surveys, as an end point in medical care (Han et al., 2018).

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NIHL is a major health disorder prevailing in Asia. Lack of healthcare access, lack of preventive management, and lack of awareness are some factors that exacerbate the situation. (Fuente and Hickson, 2011; Alshehri et al., 2019). Stone-mortar industries are one of the major sources of noise pollution, due to the noisy nature of the processes involved. Most stone-mortar factories employ informal labor. The factories then generate loud noise owing to the stone-mortar processes such as stone cutting, and stone grinding (Thongtip et al., 2020a; Thongtip et al., 2020b). These processes have a drastic effect on the health and QoL of the workers and the people living near these factories (Kitcher et al., 2012; Huang et al., 2018). Therefore, we aimed to assess the association between noise exposure and QoL among people living near stone-mortar factories in Phayao Province, Northern Thailand.

2. METHODOLOGY

2.1 Study design, population, and sampling

A cross-sectional descriptive study population was selected from people living near five stone-mortar factories (Figure 1), using a simple random sampling from February to April 2019 in Phayao Province, Northern Thailand. The stone-mortar process in each factory consisted of stone cutting and grinding. The inclusion criteria were subjects who were 18 years old and above, and had lived near the stone-mortar factories for at least one year. The exclusion criteria was subjects who were unable to communicate in Thai language.

The sample size was calculated based on the proportion of quality of life from noise exposure among Thai residents. It was eligible for further

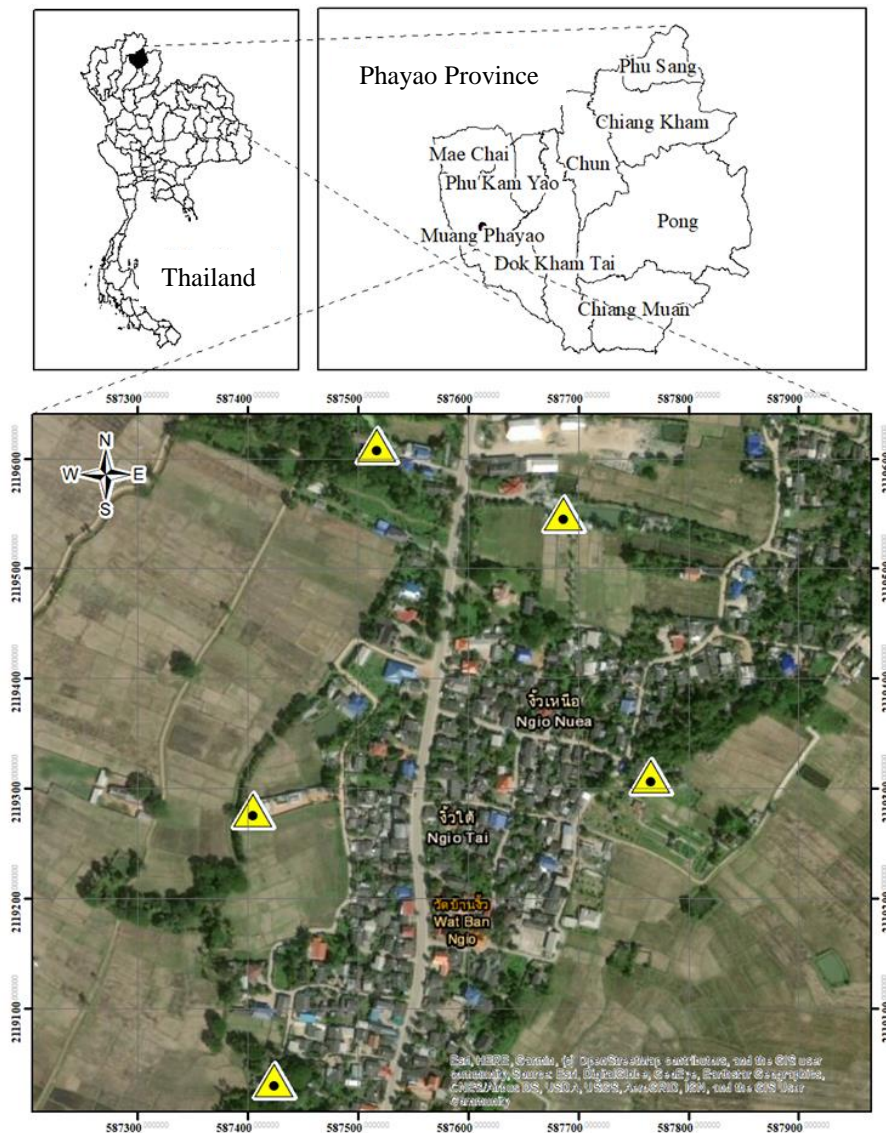


Figure 1. Stone-mortar factories in Phayao Province, Northern of Thailand

analysis at 39.42% (Padungtod et al., 2011). The equation used to obtain the sample size output:

$$n = \frac{Np(1-p)Z^2_{1-\alpha/2}}{d^2(N-1)+p(1-p)Z^2_{1-\alpha/2}}$$

Where; size of population (N) is 642; $p=0.3942$, Delta (d) is 0.05; Alpha is 0.05, Z (0.975) is 1.960; and sample size (n) is 233.7.

We added at least 15% more to the estimated sample size to allow for losses. Therefore, the sample size was required to be 269 subjects.

2.2 Data collection and measurement

The data was collected utilizing questionnaires that inquired information related to demographic data (sex, age, income, marital status, education, and occupation), lifestyle habits (cigarette and alcohol usage), residential distance, and length of stay in the community.

The noise levels were measured using 21 samplers from five stone-mortar factories. The instrument used for measuring the noise level was the sound level meter: RION, Japan calibrated with the help of a calibrator of 94 dB at 1,000 Hz. Sound level meters set on the A-scale with slow response can be used to assess the noise level effectively. The meter was set up at ear height. Furthermore, the residential distance was measured using Geographic Information System (GIS) technique.

The SF-36 is a generic measure of health status in accordance with which the questionnaire was designed. It was developed by Ware et al. (1994) and Ware et al. (1998) and the Thai version of SF-36 was translated by Jirarattanaphochai et al. (2005). The SF-36 is a questionnaire assessing the QoL with two components: PCS and MCS. It has 36 items and eight scales: physical functioning (PF), physical role limitations (RP), bodily pain (BP), general health (GH), vitality/energy/fatigue (VT), social functioning (SF), emotional role limitations (RE), and mental health (MH). Component analysis showed that there are two distinct concepts measured by the SF-36: a physical dimension, represented by PCS, and a mental dimension, represented by MCS.

2.3 Statistical analysis

Descriptive statistics illustrated frequencies, percentage, means, standard deviations, and maximum-minimum values. Inferential statistics utilized independent t-test, ANOVA, and Pearson's

correlation coefficient test. Additionally, the association of residential distance with noise exposure was estimated using the multiple binary logistic regression analysis. Statistical significance was defined at p-value <0.05.

2.4 Ethical consideration

The study was approved by the Research Ethics Committee of University of Phayao, Thailand (No. 2/079/61).

3. RESULTS

Stone-mortar factories entailed informal labor, and most people lived near the five stone-mortar factories as shown in Figure 1. The results revealed that among the participants, 166 were females (61.7%) and 103 were males (38.3%). The average age of the sample was 55.4 years old, with an average income of 4,307 baht per month. The average length of stay in community was found to be 52.2 years. Furthermore, the average distance between the residents and stone-mortar factories was calculated to be 139.3 m. The proportion of noise at ≥ 85 dB(A) was 71.4% (Table 1).

Table 1. Characteristics of sample populations

Characteristics (n=269)	n (%)
Sex	
Male	103 (38.3)
Female	166 (61.7)
Age (years), mean \pm SD	55.4 \pm 15.1
≤ 40	38 (14.1)
41-59	134 (49.8)
≥ 60	97 (36.1)
Income (baht/month), mean \pm SD	4,748.7 \pm 5,758.3
$\leq 1,000$	99 (36.8)
1,001-4,000	71 (26.4)
$\geq 4,001$	99 (36.8)
Marital status	
Single	33 (12.3)
Married	209 (77.7)
Divorce	27 (10.0)
Education	
\leq Primary school	200 (74.3)
$>$ Secondary school	69 (25.7)
Occupation	
Unemployed	68 (25.3)
Daily hired workers	79 (29.4)
Agriculture	57 (21.2)
Others	65 (24.2)

Table 1. Characteristics of sample populations (cont.)

Characteristics (n=269)	n (%)
Length of stay in the community (years), mean±SD	52.2±18.5
≤40	63 (23.4)
41-59	116 (43.1)
≥60	90 (33.5)
Cigarette usage	
No	228 (84.8)
Yes	41 (15.2)
Alcohol usage	
No	207 (77.0)
Yes	62 (23.0)
Residential distance (m), mean±SD	139.3±52.4
≤150 m	163 (60.6)
>150 m	106 (39.4)
Noise exposure (dB(A)), mean±SD	90.1±6.6
<85	77 (28.6)
≥85	192 (71.4)

The average noise in factory no. 4 and 5 was higher than the standard level assigned by the National Institute for Occupational Safety and Health (NIOSH) at 85 dB(A) and the Occupational Safety and Health Administration (OSHA) at 90 dB(A) for an 8-hour time-weighted average (TWA), while the average noise in factories no. 1 and 3 was lower than the standard level of NIOSH at 85 dB(A) and OSHA at 90 dB(A) for an 8-hour TWA (Table 2).

Table 2. Noise exposure in stone mortar factories

Stone mortar factories (n=21)	Noise level (dB(A))	
	Mean±SD	Max-Min
Factory 1 (n=4)	79.9±10.7	106.7-49.5
Factory 2 (n=2)	90.6±6.2*	105.8-47.1
Factory 3 (n=5)	83.0±10.6	102.0-52.5
Factory 4 (n=5)	93.4±8.3*	110.2-68.3
Factory 5 (n=5)	95.5±6.7*	113.4-54.8

n=number of noise samplers for each factory; *Higher than the standard level of NIOSH at 85 dB(A) and OSHA at 90 dB(A) for an 8-hour TWA (NIOSH, 2018)

Table 4. Association between demographics, health characteristics, residential distance, noise exposure, and QoL

Characteristics	PCS	p-value	MCS	p-value	Overall	p-value
Sex ^a						
Male	82.0±16.7	0.487	75.4±12.2	0.827	78.7±13.1	0.734
Female	80.7±15.4		75.7±11.6		78.2±12.1	
Age (years) ^b						
≤40	85.0±13.6	0.09	73.8±10.4	0.477	79.4±10.7	0.706

The average PCS scores obtained from the QoL assessment were found to be higher than those of the healthy Thai national volunteers. The values corresponded to 81.2 and 75.1, respectively. The average MCS and SF scores were lower than those of healthy Thai national volunteers, corresponding to 75.6, 68.8, and 76.7, respectively (Table 3).

Table 3. Mean±SD of QoL score of subjects and Thais' healthy national volunteers

QoL domains	QoL	QoL
	Overall	Thais' volunteer ^a
<i>Physical component summary (PCS)</i>	81.2±15.9	75.1±20.6
- Physical functioning (PF)	88.9±17.4	77.3±17.4
- Physical role limitations (RP)	83.2±33.4	82.2±28.6
- Bodily pain (BP)	85.5±18.6	75.6±18.4
- General health (GH)	67.2±17.6	65.1±18.1
<i>Mental component summary (MCS)</i>	75.6±11.8*	76.7±19.1
- Vitality/energy/fatigue (VT)	70.6±13.6	62.2±13.3
- Social functioning (SF)	68.8±22.0*	78.2±18.2
- Emotional role limitations (RE)	87.8±29.8	80.4±31.9
- Mental health (MH)	75.2±14.5	66.1±12.9

^aThais' healthy national volunteers (Lim et al., 2008) *Lower than the QoL Thais' volunteer

Significant differences were observed in the income, marital status, education, and PCS of people living near the stone-mortar factories. However, there were not significant differences found in demographics, health characteristics (cigarette and alcohol consumptions usage), residential distance, noise exposure, and QoL (Table 4).

There was a significant correlation found between residential distance from stone-mortar factories (m) and the noise exposure to the people living near these factories. However, there was no significant difference exhibited in the value of noise exposure and QoL of people living near stone-mortar factories (Table 5).

Table 4. Association between demographics, health characteristics, residential distance, noise exposure, and QoL (cont.)

Characteristics	PCS	p-value	MCS	p-value	Overall	p-value
41-59	81.9±14.3		75.4±11.9		78.7±11.7	
≥60	78.7±18.4		76.5±12.1		77.6±14.0	
Income (baht/month) ^b						
≤1,000	78.8±17.9	0.045*	75.7±12.8	0.729	77.3±13.9	0.192
1,001-4,000	80.2±17.4		74.7±12.1		77.4±13.0	
≥4,001	84.3±11.7		76.1±10.5		80.2±10.2	
Marital status ^b						
Single	87.5±8.5	0.039*	78.7±7.9	0.258	83.1±6.0	0.060
Married	80.0±16.7		75.1±12.5		77.8±13.2	
Divorce	78.3±15.2		75.5±9.6		76.9±10.9	
Education ^a						
≤Primary school	80.1±16.5	0.035*	75.2±11.9	0.312	77.6±12.7	0.087
>Secondary school	84.4±13.6		76.8±11.5		80.6±11.6	
Occupation ^b						
Unemployed	79.5±18.6	0.432	76.1±13.5	0.960	75.2±14.7	0.881
Daily hired workers	81.5±15.5		75.6±10.5		78.2±11.4	
Agriculture	79.9±15.5		75.6±11.8		76.4±12.2	
Others	83.7±13.6		75.0±11.6		79.0±11.4	
Length of stay in community (years) ^b						
≤40	83.2±14.3	0.145	73.2±11.0	0.166	78.5±11.3	0.683
41-59	82.1±14.3		76.1±12.0		77.4±11.9	
≥60	78.6±18.4		76.6±12.0		76.0±13.9	
Cigarette usage ^a						
No	80.9±16.0	0.538	75.3±12.2	0.305	78.1±12.7	0.380
Yes	82.6±15.2		77.3±9.4		80.0±19.7	
Alcohol usage ^a						
No	80.6±16.1	0.242	75.6±11.9	0.955	78.1±12.7	0.440
Yes	83.3±15.0		75.7±11.4		79.5±11.7	
Residential distance (m) ^a						
≤150 m	81.5±15.9	0.650	76.2±11.6	0.314	78.7±12.1	0.444
>150 m	80.6±15.9		74.7±12.0		77.7±12.9	
Noise exposure (dB(A)) ^a						
<85	79.6±18.3	0.295	74.6±13.0	0.393	77.1±14.3	0.283
≥85	81.8±14.8		75.9±11.3		78.9±11.6	

^aPresented as Independent t-test, ^bANOVA; *p<0.05**Table 5.** Association between demographics, residential distance and QoL

Characteristics	Noise exposure ^a		p-value	Noise exposure ^b p-value
	<85 dB(A)	≥85 dB(A)		
Age (years)	55.1±13.5	55.5±15.8	0.855	0.959
Income (baht/month)	5,252.8±7,751.5	3,940.9±4,568.5	0.181	0.067
Length of stay in community (years)	51.2±17.2	52.6±19.0	0.576	0.617
Residential distance (m)	129.6±43.4	123.2±55.2	0.032*	0.299
Quality of life (QoL)				
PCS	79.6±18.3	81.8±14.8	0.295	0.301
MCS	74.6±13.0	76.0±11.3	0.393	0.388
Overall	77.1±14.3	78.9±11.6	0.283	0.285

^aPresented as Independent t-test, ^bPearson's correlation coefficient test; *p<0.05

The multiple binary logistic regression analysis showed that an increasing residential distance must be associated with a high noise exposure after adjusting for age (years), education, income (baht/month), length of stay in community (years), and overall QoL (Table 6).

Table 6. Association between residential distance and noise exposure using multiple binary logistic regression analysis

Associated factors	B	SE	p-value
Residential distance (m)	0.006	0.003	0.032*

Adjust with age (years), education, income (baht/month), length of stay in community (years), and overall QoL; *p<0.05

4. DISCUSSION

Noise is an unwanted sound and excessive and prolonged exposure to noise may have adverse effects on the health of workers and people living around those noise sources (Padungtod et al., 2011; WHO, 2011). Our study found that the average distance between residents and stone-mortar factories was 139.3 m. The proportion of noise at ≥ 85 dB(A) was 71.4%. The average noise in factory no. 2, 4, and 5 was higher than the standard level of the NIOSH Recommended Exposure Limit (REL) for occupational noise exposure standard of 85 dB(A) and OSHA's permissible exposure limit (PEL) is 90 dB(A) for an 8-hour TWA (NIOSH, 2018). Noise levels above the standard level may be caused due to the work processes involved such as stone cutting and grinding, maintenance, etc. (Landen et al., 2004; Huang et al., 2018). Additionally, several studies have suggested that the sources of noise pollution should be provided engineering controls, administrative controls, and work practices to loud noise (WHO, 2001; Fonseca et al., 2016).

The average MCS and SF scores exhibited by our study were lower than those of healthy Thai national volunteers (Lim et al., 2008). Significant differences were found in income, marital status, education, and PCS of people living near stone-mortar factories. Evidence suggests that abnormal MCS and SF may be related to depressive symptoms, comorbid mental health, as well as emotional and behavioral coping. These aspects may eventually lead to lasting social impairment (McKnight and Kashdan, 2009; D'Souza et al., 2013). The findings were hence consistent with our hypothesis, that demographics are significantly associated with the QoL (Wang et al., 2008).

As aforementioned, our study found that there existed significant differences in the income, marital

status, education, and PCS of people living near stone-mortar factories. However, no significant differences were revealed in the demographics, health characteristics (cigarette or alcohol usage), residential distance, noise exposure, and QoL. There was no significant association found between noise exposure and QoL of people living near stone-mortar factories. Previous studies have found that factors such as marriage, shorter duration of stay in the community, education, economic status, enduring illness, social, cognitive, emotional and behavioral coping were significantly associated with QoL (D'Souza et al., 2013). QoL may have several possible confounding factors that affect this association such as daily activities, BMI, chronic diseases, and geographical region (Wang et al., 2008). Besides that, noise pollution is also emitted by community activities, traffic, and other industries (Ali et al., 2018; Sordello et al., 2019).

Our study found that there was significant difference between residential distance from stone-mortar factories (m) and noise exposure to people living near these factories. Interestingly, the multiple binary logistic regression analysis showed that an increasing residential distance is associated with a high noise exposure after adjusting for age (years), education, income (baht/month), length of stay in community (years), and overall QoL. The findings were inconsistent with our results that statistically significantly higher levels of environmental noise sources when compared to people living near environmental noise sources (Tenailleau et al., 2015; Boyle et al., 2017). Previous studies have suggested that increased age was the main issue with regards to hearing loss in stone-mortar workers (Thongtip et al., 2020a). This conclusion was found to be consistent with our results that the average age of people living near stone-mortar factories was 55.4 years old with an average length of stay in the community of 52.2 years. In addition to that, all stone-mortar factories were located around communities as shown in figure 1. Therefore, there are other possible determinants including socioeconomic status, air pollution, roadway proximity variables, community activities, traffic, and other industries that might be taken into consideration to reach a conclusive result (Correia et al., 2013; Ali et al., 2018; Sordello et al., 2019).

A limitation of this study was the cross-sectional design to explore the association of residential distance with noise exposure. Therefore, further research is required to focus on a longitudinal

study that factors in other aspects such as noise levels in all seasons with respect to the adverse health effects associated with living in close proximity to stone-mortar factories. Moreover, further research should measure noise levels in the receptors or people living near these factories.

To conclude, findings of this study indicate that people living near stone-mortar factories are being exposed to low environmental noise. In order to examine the detrimental effects of the same, other possible confounders might be taken into consideration. However, the average noise in some factories was found to be higher than the standard level of NIOSH at 85 dB(A) and OSHA at 90 dB(A) for an 8-hour TWA. Therefore, the local policy makers should be required to emphasize the reduction of noise pollution in stone-mortar factories, and increase the health surveillance of the residential neighborhood.

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