EnvironmentAsia
The international journal by the Thai Society of Higher Education Institutes on Environment

EnvironmentAsia 12(3) (2019) 140-150
DOI 10.14456/ea.2019.54
ISSN 1906-1714; ONLINE ISSN: 2586-8861

Association of Health-Related Quality of Life with Residential Distance from Home Stone-Mortar Factories in Northern Thailand

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Received: August 28, 2018; Revised: January 30, 2019; Accepted: June 16, 2019

Abstract

Particulate matter less than 10 µm in diameter (PM_{10}) from home industry has a huge impact on the environment, adversely affecting respiratory symptoms and quality of life. We aimed to assess the health-related quality of life (HRQOL), respiratory symptoms and residential distance. A cross-sectional study was carried out with 380 subjects who were interviewed using the SF-36 Quality of Life Instrument, respiratory symptoms also being assessed. Residential distance was measured using a geographic information system (GIS) tool. PM_{10} and crystalline silica concentrations were measured by 41 samplers from 11 stone-mortar factories. The results showed that the average PM_{10} and silica concentrations were lower than recommendations by NIOSH and ACGIH, while the crystalline silica concentrations were higher. The average scores of the physical components HRQOL were higher than those of a control group of Thai volunteers. The overall HRQOL findings were significantly different in age, income, education, occupation, respiratory symptoms, underlying diseases and residential distance. The multivariable analysis indicated that residential distance was associated with physical, mental and overall HRQOL after adjusting for age, respiratory symptoms and underlying diseases. Therefore, the local policy makers need to facilitate the reduction in air pollution from stone factories to improve respiratory health and quality of life.

Keywords: HRQOL; Respiratory symptoms; Stone-mortar; PM_{10}; Crystalline silica; GIS

1. Introduction

Air pollution is a major environmental risk to human health. Various sources of air pollution are emitted by natural and artificial sources such as cigarette smoking, motor vehicles, agriculture, and industrial activities (Guttikunda *et al.*, 2014; Ghorani-Azam *et al.*, 2016). Particulate matter (PM_{10}), which can especially have a major impact on respiratory health as it enters the lungs through the respiratory system. Exposure to PM_{10} can cause respiratory illnesses, adverse health effects, and result in a poor quality of life for residents living near air pollution sources (Brunekreef *et al.*, 2005; Kim *et al.*, 2005; Darçın, 2014; Guo *et al.*, 2014).

In addition, the concentration levels of PM_{10} were found to cause harm or discomfort to related physical health and mental health in people directly exposed to the pollutant and also the local residents (Krewski, 2009; Darçın, 2014). Therefore, health effects of PM_{10} exposure and ambient air pollution can be a predictor of quality of life (QOL) both for physical health and psychological well-being. Other researchers found that the residents who live near air pollution sources in both inside and outside countries, were affected in both physical and mental health (Zullig *et al.*, 2010; Fleury-Bahi *et al.*, 2015).

Moreover, the quality of life in communities living near air pollution sources had higher physical health and mental health problems than communities living far from air pollution sources when comparing the quality of life using the SF-36 (D'Souza *et al.*, 2013; Fleury-Bahi *et al.*, 2015).This is particularly evident if the residents of rural areas have the education and knowledge to effectively and efficiently control air pollution to maintain low levels (Liao *et al.*, 2015). Several studies have found that the application of a geographical information systems (GIS) tool has the potential to assess the environmental problems which affect human health and epidemiology. A GIS tool enables precise measurements of the spatial pattern between the distance from the resident's location and air pollution sources, which are in close proximity to the residents (Thornton *et al.*, 2011; Wang *et al.*, 2015; McCracken *et al.*, 2016).

In Thailand, stone-mortar production has for a long time primarily been an informal labor-intensive cottage industry. These processes can generate PM_{10} or very small particles which contain crystalline silica, the particulate matter spreading throughout the workplaces and communities. Furthermore, the exposure to and subsequent passage of PM_{10} containing crystalline silica into the lungs in both the short and long term can cause respiratory symptoms, impaired pulmonary function and silicosis. Previous studies found evidence that stone-mortar production can have an impact on the quality of life of people living in the neighborhood around air pollution sources (Wang *et al.*, 2008; Darçın, 2014; Mohammadi *et al.*, 2017; Silanun *et al.*, 2017). Therefore, we aimed to assess the health-related quality of life (HRQOL), respiratory symptoms and distance between home and stone-mortar factories among residents in the vicinity of Phayao Province, Thailand.

2. Materials and Methods

2.1 Study design, Population, and sampling

This study was a cross-sectional study into the residents living in close proximity to 11 stone-mortar factories. Forty-one stone-mortar workers, who were employed in stone-mortar factories, were measured for PM_{10} and crystalline silica concentrations with personal samplers. The data were collected using questionnaires during January-March 2017 in two villages of the Ban Sang Sub-District, Phayao Province in Northern Thailand. We used a simple random sampling method, and a sample size was calculated for estimating the proportion of a finite population. Consequently, 380 subjects (43.9%) of a total population of 866 people were selected. The remaining subjects were eligible for further analysis from the formula based on the proportion of quality of life at 29.5% (D'Souza *et al.*, 2013). The sample size calculation using n4Studies (Ngamjarus, 2016) is as follows:

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

N = 866, p = 0.295, Delta = 0.035, Alpha = 0.05, Z(0.975) = 1.960, Sample size = 373

We added at least 5% to the estimated sample size to allow for losses. Therefore, the sample size needed to be 392 subjects. Inclusion criteria for the participants were those who were not stone-mortar workers, were 18 years old and above, had lived for at leastone year in the studied area and had signed consent forms. Exclusion criteria included people who could not verbally communicate in Thai and those who had neuropathy.

2.2 Data Collection and Measurement

The participants sign edconsent forms before the data collection. A questionnaire was administered by trained research assistants to collect data from the study subjects. The questionnaires included the collection of demographic data (sex, age, income, marital status, education, occupation and length of living in this community), medical history (respiratory symptoms, underlying diseases such as hypertension, diabetes mellitus, bronchitis, chronic obstructive pulmonary disease, heart disease,stroke, asthma, emphysema, tuberculosis, pneumonia and allergies), smoker and alcohol user and HRQOL.

The SF-36 is a standard or generic questionnaire for assessing quality of life which has been used extensively worldwide. This questionnaire was made into the form of a manual by Ware *et al.* (Ware *et al.*, 1994; Ware *et al.*, 1995; Ware *et al.*, 1998), and the SF-36 version 2 was translated into Thai by Jirarattanaphochai *et al.* (2005).The SF-36 questionnaire contains 36 questions categorized into two main components, specifically a physical component summary (PCS) and a mental component summary (MCS). The SF-36 measures eight health concepts: 1) physical functioning (PF) (10 items); 2) role limitations due to physical problems (RP) (4 items); 3) bodily pain (BP) (2 items); 4) general health (GH) (5 items); 5) vitality (VT) (4 items); 6) social function (SF) (2 items); 7) role limitations due to emotional problems (RE) (3 items); 8) mental health (MH) (5 items), and one single item dimension on health transition. Each dimension results in a score in the range of 0-100 with a higher score indicating a better quality of life. The scores assigned to all question items can be categorized for computation of total component score, specifically PCS and MCS.

The standardized American Thoracic Society Division of Lung Disease questionnaire (ATS-DLD-78A) was used in the interviews. The questionnaire includes respiratory symptoms such as coughing, phlegm, coughing with phlegm, wheezing, difficulty in breathing, chest pain, nose irritation and stuffy nose (Helsing *et al.*, 1979).

The geographic positions or coordinates of the stone-mortar factories and those of the residents living in the vicinity of stone-mortar factories were identified using the Garmin eTrex 30x GPS tool and the information was used for calculating the distance between the stone-mortar factories and the residential home. In addition, the geospatial data obtained were processed into map form using direct measurements using the QGIS program.

Personal exposures to PM_{10} and silica were assessed using personal sampling following the National Institute for Safety and Health guidelines; the NIOSH method 0600 (NIOSH, 1998) and 7601 (NIOSH, 2003). PM_{10} was collected using a nylon cyclone and calibrated with a soap bubble meter at a flow of 1.7 L/min. All samplings were performed using Polyvinyl chloride (PVC) filters. The personal sampling was completed in the workers' breathing zones. All of the PM_{10} filters were weighed before and after sampling to analyze the level of PM_{10} followed by analysis for silica with spectrophotometry.

2.3 Ethical Considerations

The study was approved by the Research Ethics Committee of the Faculty of Medicine, Chiang Mai University, Thailand (No. 243/2016).

2.4 Statistical Analysis

The data were analyzed using R 2.13.0 for windows for descriptive statistics on characteristics of participants, medical history, smoking and alcohol use and HRQOL scores. These data were analyzed by an independent t-test and analysis of variance (ANOVA). The association between the distance between home and stone-mortar factories and the HRQOL of the residents living in the vicinity of stone-mortar factories were analyzed by multivariate regression analysis.

3. Results

3.1 Sample Characteristics

Gender of the participants were 158 males (41.6%) and 222 females (58.4%). The average age was 55.6 years old with an average income of 4,274.2 baht/month (~133.6 US dollars). The average length of living in this community was 52.4 years. The sample populations who had no respiratory symptoms or underlying diseases were 67.1% and 71.8%, respectively. The average distance between home and stone-mortar factories was 96.3 meter. The proportion of residential distance within 100 meter was 49.7% (Table 1).

3.2 Stone-mortar factories locations and the concentration of PM_{10} and crystalline silica

The average distance of stone-mortar factories located far from other factories (no 1, 2, 3, 4, 8 and 9) was 174.5 m (Min = 90, Max = 246, mean = 174.5, SD = 65.0), and the

Table 1. Characteristics of sample populations

Characteristics (N= 380)	n (%)
Sex	
Male	158 (41.6)
Female	222 (58.4)
Age (years), mean±SD	55.6±15.3
≤25	17 (4.5)
26-45	56 (14.7)
46-64	217 (57.1)
≥65	90 (23.7)
Income (Baht/month), mean±SD	4274.2±5574.4
≤1,000	148 (38.9)
1001-4000	98 (25.8)
4001-8000	80 (21.1)
≥8001	54 (14.2)
Marital status	
Single	59 (15.5)
Married	285 (75.0)
Divorce	36 (9.5)
Education	
Primary school	273 (71.8)
Secondary school	64 (16.8)
Higher secondary school	43 (11.3)
Occupation	
Daily hired workers	168 (44.2)
Agriculture	95 (25.0)
Unemployed	93 (24.5)
Company and government employee	19 (5.0)
Students	5 (1.3)
Length of living in this community (years), mean±SD	52.4±18.3
≤20	19 (5.0)
21-40	70 (18.4)
41-60	174 (45.8)
≥60	117 (30.8)
Smoker	
No	322 (84.7)
Yes	58 (15.3)
Alcohol user	
No	280 (73.7)
Yes	100 (26.3)
Respiratory symptoms	
No	255 (67.1)
1 symptom	40 (10.5)
>1 symptoms	85 (22.4)
Underlying diseases	
No	273 (71.8)
1 disease	68 (17.9)
>1 diseases	39 (10.3)
Residential distance from stone-mortar factories (meters), mean±SD	
<100 meters	96.3±40.3
≥100 meters	189 (49.7)
	191 (50.3)

distribution pattern is shown as Pattern A in Figure 1. The average distance of stone-mortar factories located close to others (no 5, 6, 7, 10 and 11) was 68.9 meters (Min = 53.0, Max = 77.0, mean = 68.9, SD = 11.4). These formed a cluster pattern shown as Pattern B in Figure 1. The average PM_{10} concentration of stone-mortar workers in pattern A was higher than that in Pattern B (0.261 ± 0.107, and 0.127 ± 0.026 mg/m^3, respectively). The average silica concentration of the stone-mortar workers in Pattern A was higher than Pattern B (0.152 ± 0.066, 0.070 ± 0.016, respectively). The average concentrations of crystalline silica in both patterns were higher than both the National Institute for Safety and Health (NIOSH) and the American Conference of Government Industrial Hygienist (ACGIH), which allowed an extent of 0.025 mg/m^3. The PM_{10} and silica concentrations were associated differently in both patterns of stone-mortar factories locations ($p<0.001$) (data not shown).

3.3 Health-related quality of life (HRQOL)

Scores from the HRQOL of the sample populations found that the average PCS scores were higher than those of the healthy Thai national volunteers as follows: 79.2 and 75.1, respectively. The average MCS scores were slightly lower than those of healthy Thai national volunteers as follows: 75.2 and 76.7, respectively. Average RP, SF and MCS scores were lower than those of the non-resident Thai national volunteers (Table 2).

3.4 Association between demographic, health characteristics, residential distance and HRQOL

There were significant differences between age, income, marital status, education, occupation, period of living in this community, alcohol use, underlying diseases

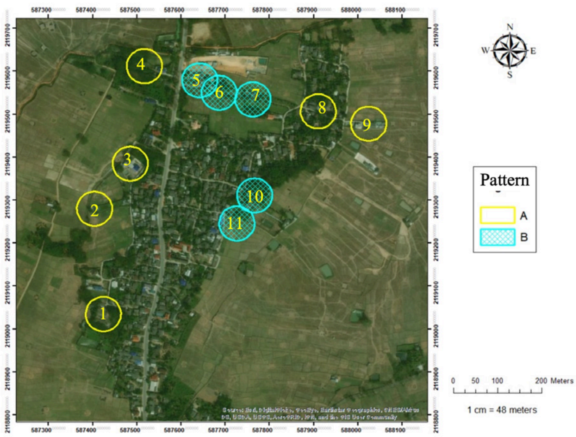

Figure 1. Pattern A: cluster pattern, with six stone-mortar factories (no 1, 2, 3, 4, 8 and 9); Pattern B: distribution pattern, with five stone-mortar factories (no.5, 6, 7, 10 and 11)

Table 2. Mean±SD of HRQOL score of sample populations and Thais' healthy national volunteers

HRQOL Domains	HRQOL Overall	HRQOL Thais' volunteer [a]
Physical component summary (PCS)	79.2±17.2	75.1±20.6
Physical functioning (PF)	86.6±20.2	77.3±17.4
Physical role limitations (RP)	79.6±35.3	82.2±28.6
Bodily pain (BP)	83.8±18.6	75.6±18.4
General health (GH)	66.8±19.1	65.1±18.1
Mental component summary (MCS)	75.2±12.8	76.7±19.1
Vitality/energy/fatigue (VT)	70.1±14.6	62.2±13.3
Social functioning (SF)	71.0±22.3	78.2±18.2
Emotional role limitations (RE)	84.6±33.1	80.4±31.9
Mental health (MH)	75.1±15.8	66.1±12.9

[a] Thais' healthy national volunteers (Lim *et al.*, 2005)

and PCS of people living in the vicinity of stone-mortar factories. In some of the MCS, there were significant differences between income, education, respiratory symptoms, and underlying diseases. The overall HRQOL was significantly different as regards age, income, education, occupation, respiratory symptoms and underlying diseases. Moreover, the distance between home and stone-mortar factories of people living in the vicinity of stone-mortar factories were significantly different as regards PCS, MCS and overall HRQOL (Table 3).

3.5 Association between respiratory symptoms and HRQOL

The respiratory symptoms of chest pain and stuffy nose were significantly different to the overall HRQOL scores. Moreover, subjects with respiratory symptoms had PCS, MCS and overall HRQOL scores lower than subjects without respiratory symptoms. The most common symptoms were cough (20.8%), phlegm (13.2%), nose irritation (12.6%), stuffy nose (12.1%), chest pain (11.6%) and cough with phlegm (10.5%) (Table 4).

3.6 Association between residential distance from stone-mortar factories and HRQOL

The multivariable analysis indicated that residential distance was associated with physical, mental and overall HRQOL after adjusting for age, respiratory symptoms and underlying diseases. Also an increased distance between home and stone-mortar factories was associated with higher physical HRQOL, mental HRQOL, and overall HRQOL (Table 5).

4. Discussion

Outdoor air pollution and particulate matter are classed as Group 1 human carcinogens by the International Agency for Research on Cancer (Loomis *et al*., 2014), and it is accepted that they affect physical health, mental health and quality of life. The pollutants, especially PM_{10} and crystalline silica can lead to respiratory disease and increased mortality, and other diseases including lung cancer, chronic obstructive pulmonary diseases, asthma, and silicosis (Darçın, 2014; Guo *et al*., 2014; Silanun *et al*., 2017). The generic SF-36 tool has been extensively used worldwide for assessing the quality of life of exposed persons and people living near the air polluting sources (Lim *et al*., 2008; Wang *et al*., 2008).

Our studies found that the people living in the vicinity of household stone factories, especially the residents living near stone factories within distances of less than 100 meters often had symptoms of respiratory diseases. These symptoms can lead to an increased risk of poorer health status, more psychosocial stressors and a decreased quality of life. Several studies found the association between the short- and long-term effects of air pollution exposure can be induced by socioeconomic change, demographic characteristics, and the quality of life of both directly exposed workers and the people living in the vicinity of stone factories (Laurent *et al*., 2007; Wang *et al*., 2008; Krewski, 2009; D'Souza *et al*., 2013; Darçın, 2014).

In addition, primary factors, demographics, socioeconomics, and geographical regions have been identified as being related to the quality of life (HRQOL). All of these were associated with the quality of life of residents of communities living near air pollution sources. These findings were consistent with our results, specifically, those characteristics of participants, medical history, and lifestyle habits identified in the HRQOL scores of people living in the vicinity of stone-mortar factories (Wang *et al*., 2008; D'Souza *et al*., 2013).Therefore, if possible, changes should be made to address primary factors, socio-economic, and geographical region for residents of communities living near areas with high particulate air pollution, which could lead to increases in life expectancy (Krewski, 2009).

In addition, residents in communities located closer to air pollution sources were more likely to have poorer physical health, mental health, and quality of life than those living at greater distance from the air pollution sources (D'Souza *et al*., 2013). Most importantly, residents of communities that can easily be exposed to the dispersing of pollutants in ambient air pollution, for example those living near air pollution sources, need advice and support regarding self-preventive measures to protect themselves (Zullig *et al.*, 2010; D'Souza *et al.*, 2013).

The multivariate analysis indicated that residents living near stone-mortar factories tended to have a significantly negative HRQOL. This finding was also consistent with previous studies which showed that the residents living near air pollution sources tended to have a significantly negative HRQOL in the physical and environmental domains (Lee *et al.*, 2006; Balmes *et al.*, 2009). There are many possible confounding factors that could affect this association such as living near roads, traffic noise (Roswall *et al.*, 2015) or other pollution

Table 3. Association between demographics, health characteristics, residential distance and HRQOL

Characteristics	PCS	*p*-value	MCS	*p*-value	Overall	*p*-value
Sex [a]						
Male	80.0±17.3	0.408	75.3±13.1	0.870	77.7±13.7	0.549
Female	78.6±17.2		75.1±12.7		76.8±13.6	
Age (years) [b]						
≤25	87.7±11.7	<0.001**	78.6±9.6	0.492	83.2±8.5	0.006**
26-45	84.6±11.3		75.8±10.0		80.2±9.5	
46-64	79.5±15.8		75.3±12.6		77.4±12.7	
≥65	73.4±22.1		73.8±15.3		73.6±17.5	
Income (Baht/month) [b]						
≤1,000	75.1±20.1	0.001**	73.6±14.3	0.035*	74.3±15.8	0.004**
1001-4000	80.2±17.4		75.5±12.6		77.8±13.3	
4001-8000	83.5±9.7		78.6±8.6		81.1±8.1	
≥8001	82.1±14.9		74.1±13.6		78.1±13.1	
Marital status [b]						
Single	83.4±12.7	0.030*	77.6±11.4	0.251	80.5±10.3	0.054
Married	79.0±17.6		74.9±13.1		76.9±14.0	
Divorce	73.9±19.5		73.8±12.6		73.8±14.9	
Education[b]						
Primary school	77.5±18.2	0.007**	74.2±13.2	0.014*	75.8±14.3	0.004**
Secondary school	84.4±13.6		79.4±10.7		81.9±10.9	
Higher	82.3±13.3		75.1±12.7		78.7±11.6	
Occupation [b]						
Daily hired workers	82.1±13.7	0.003**	76.1±11.1	0.130	79.1±11.0	0.030*
Agriculture	78.3±16.1		75.3±13.0		76.8±13.1	
Unemployed	73.7±22.8		73.8±15.7		73.8±18.0	
Company and government employee	83.0±13.5		71.0±11.2		77.0±11.5	
Students	83.5±16.9		85.3±4.4		84.4±8.3	
Length of living in this community (years) [b]						
≤20	83.4±16.2	0.005**	74.3±11.5	0.897	78.9±12.4	0.111
21-40	82.9±13.0		75.2±10.9		79.0±10.3	
41-60	80.2±15.6		75.7±12.7		77.9±12.8	
≥60	74.8±20.8		74.6±14.4		74.7±16.4	
Smoker [a]						
No	78.9±17.6	0.535	75.1±13.1	0.739	77.0±14.0	0.584
Yes	80.5±15.3		75.7±11.1		78.1±11.8	
Alcohol user [a]						
No	78.0±18.3	0.012*	74.6±13.1	0.105	76.3±14.3	0.016
Yes	82.4±13.4		77.0±11.9		79.7±11.2	
Respiratory symptoms [b]						
No	80.0±16.5	0.062	76.5±11.9	0.008**	78.2±12.7	0.018*
1 symptom	82.1±12.5		74.7±11.2		78.4±10.1	
>1 symptoms	75.5±20.6		71.5±15.5		73.5±16.9	
Underlying diseases [b]						
No	81.4±16.0	<0.001**	76.2±12.7	0.033*	78.8±13.1	<0.001**
1 disease	75.9±16.9		73.8±11.7		74.9±12.5	
>1 diseases	69.4±21.7		70.8±14.8		70.1±16.7	
Pattern of stone-mortar factories location [a]						
Cluster Pattern B	78.6±17.7	0.465	75.2±12.8	0.989	76.9±13.9	0.650
Distribution Pattern A	79.9±16.5		75.2±13.0		77.6±13.4	
Residential distance from stone-mortar factories (meters) [a]						
<100 meters	81.5±13.5	0.008**	76.8±10.9	0.014*	79.2±10.7	0.005**
≥100 meters	76.9±20.0		73.6±14.4		75.2±15.8	

[a] Presented as Independent t-test, [b] ANOVA; * $p<0.05$, ** $p<0.01$

sources. Furthermore, buildings or other obstructions might be influencing factors in the decrease of air pollution levels (Yang *et al*., 2015). Wind direction has also been shown to affect air quality and needs to be taken into consideration (Guerra *et al*., 2006).

One strength of this study was the use of the GIS tool to assess the residential distance between home and stone-mortar factories giving a high level of accuracy. In addition, this study rather than monitoring total particulate matter in the air breathed by stone-mortar workers monitored the separate concentrations of PM_{10} and silica exposure which gives a clearer picture to help in the fight against air pollution. A limitation of this study was the lack of a procedure to measure the ambient air quality at the household in the communities. Consequently, in future studies we would measure air pollution levels and PM_{10} concentration both inside and outside of the household and examine other factors related to the health and the quality of life.

5. Conclusions

Although developing industries provide socioeconomic advantages to workers and residents living near air pollution sources, these advantages create health risks and affect the

Table 4. Association between respiratory symptoms and HRQOL

Symptoms	n (%)	HRQOL, mean±SD			*p*-value [a]
		PCS	MCS	Overall	
Cough					
No	301 (79.2)	79.4±16.9	75.5±12.6	77.5±13.3	0.441
Yes	79 (20.8)	78.4±18.5	73.9±13.8	76.1±14.8	
Phlegm					
No	330 (86.8)	79.7±16.5	75.9±12.4	77.7±13.0	0.164
Yes	50 (13.2)	75.6±21.2	72.6±15.5	74.1±17.3	
Cough with phlegm					
No	340 (89.5)	79.7±16.5	75.5±12.4	77.6±13.0	0.194
Yes	40 (10.5)	74.5±22.4	72.9±16.0	73.7±18.1	
Wheezing					
No	359 (94.5)	79.3±17.1	75.4±12.7	77.3±13.5	0.371
Yes	21 (5.5)	77.1±19.5	72.0±14.7	74.6±16.2	
Difficulty in breathing					
No	358 (94.2)	79.5±16.9	75.6±12.3	77.5±13.2	0.189
Yes	22 (5.8)	74.5±22.4	69.1±18.7	71.8±19.5	
Chest pain					
No	336 (88.4)	79.9±16.9	75.9±12.5	77.9±13.3	0.004**
Yes	44 (11.6)	73.7±18.9	69.6±14.0	71.7±15.4	
Nose irritation					
No	332 (87.4)	79.7±16.6	75.9±12.0	77.8±12.9	0.069
Yes	48 (12.6)	75.3±21.1	70.5±16.9	72.9±17.7	
Stuffy nose					
No	334 (87.9)	79.7±16.8	76.0±12.1	77.8±13.0	0.046*
Yes	46 (12.1)	75.4±199	69.6±16.7	72.5±17.0	

Presented as Independent t-test; [a] *p*-value of Overall HRQOL; * $p<0.05$, ** $p<0.01$

Table 5. Association of residential distance between home and stone-mortar factories with HRQOL using multiple linear regression analysis

Associated factors	B	SE	*p*-value
Physical HRQOL (PCS)			
Residential distance from stone-mortar factory	-0.042	0.021	0.043*
Mental HRQOL (MCS)			
Residential distance from stone-mortar factory	-0.032	0.016	0.047*
Overall HRQOL			
Residential distance from stone-mortar factory	-0.037	0.017	0.026*

Adjusted for age, respiratory symptoms and underlying diseases; * $p<0.05$

quality of life when there is a lack of control measures regarding air polluting sources. Our study showed that people experienced higher levels of respiratory diseases symptoms. It was also shown that living near pollution sources will lead to a decrease in the quality of life. Therefore, the local policy makers should aim to establish practices and procedures to reduce household air pollution from stone factories to improve the quality of life. Moreover, these findings indicate the importance of the intervention and surveillance measures, especially for residents with respiratory symptoms, to reduce the risks of air pollution exposure and lead to better health.

Declaration of Conflict of Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Acknowledgements

The authors thank all participants, the Health Promotion Unit and Sub-District Municipality in Ban Sang Sub-District, Phayao Province, Thailand. The funding support for this study came from the Faculty of Medicine, Chiang Mai University, Thailand, Grant no. 129/2559. Additionally, we would like to thank the Faculty of Medicine, Chiang Mai University for facilitating the editing of the manuscript by a professional English proofreader.

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