Predictors for Preventive Behaviors of Health Hazards from Dust Exposure among the Elderly in a Semi-Urban Community

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Abstract

A semi-urban community area used for agricultural activities was transformed into an industrial factory, which affected human health, especially among the elderly. This cross-sectional study aimed to elucidate the predictors for preventive behaviors of health hazards from dust exposure among the elderly in a semi-urban community. A total of 280 elderly participated in the study. All were living in the Kusuman District, Sakon Nakhon Province, Thailand; an approximate 2km^2 area with a sugar factory. The data measurement instrument was a questionnaire, which the researchers used to collect participant demographics, home environment, and knowledge and behaviors to prevent health hazards from dust exposure. A descriptive statistical and stepwise multiple regression analysis for the factors related to, and factors predictive of, preventive behaviors of health hazards from dust exposure were analyzed. The results revealed that 87.5% of the participants had knowledge of dust prevention practices at a high level, and 54.3% demonstrated preventive behaviors of health hazards from dust exposure at a low-moderate level. The sample had experience of dust exposure from industrial factories (52.5%). The home environment analysis found that 73.2% of the participants had houses next to roads and were exposed to dust from soil diffusion caused by traffic. The factors that could predict preventive behaviors consisted of experience of dust exposure from factories, relevant knowledge, health information from public healthcare officials, and length of stay in the area. The best predictors for preventive behaviors in the elderly population were experience of dust exposure from factories ($\beta = 0.88$, $p < 0.001$), followed by knowledge ($\beta = 0.62$, $p < 0.001$). Based on the findings of this study, healthcare providers should develop activities that contribute to the elderly taking preventive measures to reduce their dust exposure, in particular activities that enhance their knowledge of how to avoid dust exposure, while also focusing on the risks to health.

Keywords: Health hazards, Dust exposure, Semi-urban society, Elderly

What was Known

- High-risk employees in industrial areas report high prevention practices
- Predictors are occupation, residential location, and workplace

What's New and Next

- Elderly people who were exposed to dust and who received advice showed higher prevention behaviors

- Longer stays in a semi-urban community predicted lower dust prevention practices
- Enhance ability of the elderly to be role models of dust prevention

Introduction

Nowadays, particulate matter (PM) or dust in the atmosphere has become a major air pollution problem. Dust in Thailand has a variety of sources and varies from area to area[1]. Over the past 20 years, the Northeastern region of Thailand has had rapid economic development. In the past, 46.53% of land in rural areas was used for agricultural purposes, as economic activities depended mainly on agriculture. Later, the use of land changed from agricultural purposes to industria l purposes including the manufacturing of products for export, and factories were built in many provinces. This became a source of air pollution in the atmosphere, which needed to be controlled[1-3]. Moreover, many areas were transformed from rural communities to semi-urban communities. New roads were built, serving as economic routes for exporting products to foreign countries. This caused a change in lifestyle among the people, especially because their main occupations changed from rice farming to sugarcane and cassava farming, as well as harvesting agricultural produce to be sent to a factory.

As a result of such changes, and the expansion of industrial factories, semi-urban communities have had to deal with dust and air pollution[4-8]. The primary air pollution of concern is particulate matter with an aerodynamic diameter of 2.5 mm or less (PM 2.5), which is associated with many adverse health effects. The World Health Organization (WHO)[9] determined that PM2.5 is an indicator of health risks related to air pollution. WHO air quality guidelines specify that the typical 24-hour atmospheric air quality standard of PM 2.5 concentrations should not exceed 25 μg/m^3. The Thailand Pollution Control Department (TPCD)[1] specifies that it should not exceed 50 μg/m^3. Previous studies have found that in factory areas the particulate matter is always higher than the standard during production periods[9-10]. 90.5% of people who live in villages located near the factories have experienced symptoms of dust-related illnesses, including symptoms of dust allergy, coughing, sneezing, body rash, eye irritation, and red eyes[6,10,11].

The likelihood and severity of health hazards due to dust exposure depend on many factors. The main factors are: 1) the amount of dust received, 2) the duration of exposure, 3) the activities performed, such as outdoor exercise at different levels of low or high intensity, 4) personal factors, such as age and sensitivity, and 5) external factors, such as occupation, location, and the condition of the workplace or residence[12-14]. These factors will affect the severity of the symptoms in each individual differently. In the elderly, the increased amount and size of particulate matter can increase the likelihood of a person's respiratory illness by 17%. It is also the leading cause of death among the elderly, with an annual ratio of 10:1,000 when exposed to air pollution[15].

As the elderly have heart problems and lower lung efficiency, they are at greater risk of facing health hazards from dust exposure when compared to other groups[16-17]. Therefore, the elderly should adopt measures to reduce health risks related to dust exposure, to reduce risk to themselves and their family members. These preventive measures include being aware of health hazards from dust exposure and protecting themselves from dust exposure, such as by refraining from or avoiding dust-producing activities, and avoiding outdoor activities or exercising outdoors. If it is necessary to go out, they should wear a protective mask. Other preventive measures include cleaning their house to reduce the amount of dust, keeping doors and windows closed, and turning on a fan to keep the air circulating[18-20].

Sakon Nakhon is a province in the northeastern region of Thailand. It has many industrial factories in semi-urban communities, including a sugar factory in Kusuman district, because it has economic routes that connect it to the neighboring provinces of Nakhon Phanom and Mukdahan, which are also routes to Lao PDR. The sugar mill operates its machinery to produce sugar for about four months a year, from December to April, which is the time when sugarcane is harvested for delivery to the factory. The factory has to operate its machines all the time to support the amount of sugarcane that enters the factory[21]. Dust generated from sugar factories has been reported at sizes ranging from 0.08 to 9.00 mm[22]. In some areas, sugarcane leaves are also burned, leaving only the sugarcane stalks, which makes cutting the sugarcane faster because no time is wasted peeling the leaf sheaths[23]. During this pre-harvest burning of sugarcane, PM10 1807 μg/m^3 and PM2.5 had the most significant impact on health[24-25]. The burning occurs from cool to hot season (December to April) with dry and stagnant weather that can result in dust being suspended in the atmosphere for a long time. Thus, the problem of dust is more severe[26]. Disease statistics related to air pollution in the area found that the number of respiratory diseases in patients have increased from 137 in 2020 to 158 in 2021, conjunctivitis from 120 to 195 people, and dermatitis from 124 to 243 people. Most of the patients are elderly compared to other groups[27].

Regarding the PM2.5 concentrations in Kusuman district, a concentration of 27 µg/m^3 in 2017 increased to 29 and 31 µg/m^3 in 2018 and 2019, respectively. The days exceeding the air quality standard also increased from 8 days in 2017 to 14 days in 2019[6]. This made people more vulnerable to health hazards from dust exposure. If an area has a high amount of dust for a long duration, while the proportion of elderly people in the population continues to increase, the long-term health and environmental issues will ignite public concern[17]. However, health hazards can be reduced if the elderly engage in behaviors to prevent health risks from dust exposure. Therefore, this research aimed to study the behaviors and factors that predicted health risk prevention behaviors from dust exposure among the elderly living in a semi-urban community located near industrial factories in an area that has seen an upward trend in the number of days with PM2.5 concentrations over the standard[19]. This data could be useful for public health agencies, as it could be used to promote preventive behaviors of health hazards from dust exposure among the elderly by dealing with behavior-related factors which in turn could reduce the likelihood and severity of health hazards from dust exposure and lead to a better quality of life.

Materials and Methods

Ethical considerations

This study was approved by the Ethics Committee for Research Involving Human Subjects, Sakon Nakhon Rajabhat University, Thailand (Approval Number: 049/2020). Written consent was obtained from all participants before the start of the study. Participants were assured that their information would be kept confidential.

Study design and setting

A cross-sectional study was carried out with the elderly living in 17 villages in the Kusuman District, Sakon Nakhon Province, Thailand. This area is not more than 2 km^2 and includes a sugar factory. The concentration of PM2.5 in the atmosphere in this area was assessed by the AERONET network (AERosol RObotic NETwork) and the SKYNET network by Kumharn et al[6]. The PM2.5 concentration had been increasing for three years (2017-2019).

Research volunteers

The total population of elderly was found to be 784. A sample population of 280 elderly was calculated using the Krejcie and Morgan[28] sample size table. Participants' enrollment in the study was based on census, and the sample was selected by simple random sampling. The inclusion criteria were: age 60 years or over, an ability to communicate in Thai, the absence of hearing or speaking limitations, and a willingness to participate freely in the study. The exclusion criteria were an inability to provide information throughout the inquiry.

Research instrument

The instrument was a questionnaire created by the researcher from a literature review. The tool used for collecting data was divided into three sections as follows:

1. General characteristics were chosen based on a literature review, and measured using a structured questionnaire divided into six parts as follows: (1) demographic characteristics, including sex, age, marital status, education level, and length of stay in area; (2) health history, including chronic disease (diabetes mellitus, hypertension, cardiovascular disease, and more than one disease) and symptoms seen in the past month (March to April), including no symptoms, stuffy nose, itchy eyes, itchy skin, and rash; (3) protective behaviors of dust exposure (none, stay at home to avoid dust exposure, using a cloth or a mask to cover nose and mouth, turning on a fan for air circulation, opening windows for air circulation, using several preventative measures together); (4) source of health information obtained by a closed-ended, yes or no question, including public healthcare officials, television/village radio broadcasts, family members, internet/application, newspaper / leaflets / posters; (5) the environment surrounding the home obtained by four closed-ended questions, for example: "which of the following is the environment around your home?", with answer options of: house with roadside, car exhaust exposure, dust exposure from construction near the house, usage of charcoal stoves for cooking or grilling; (6) experience of dust exposure obtained by a question regarding that dust sources that participants have been exposed to in the past three months, including industrial factories and agricultural burning such as rice straw or sugarcane, garbage, or leaf litter. Answers were provided using a binary outcome scale (yes/no) for each question.

2. Preventive knowledge of health hazards from dust exposure was assessed using 10 items on the questionnaire. For example, "dust is caused by burning agricultural waste or burning garbage in open areas" and "doing outdoor activities when the level of small particulate matter exceeds the standard will make it

it possible to get sick." Scoring was based on choosing the correct or incorrect answer, or unsure answer. The correct answer was given 1 point, and wrong or unsure answers were given 0 points. Possible scores ranged between 0-10 points, divided into two categories: low to moderate 0-7, and high ≥8. Then, three experts validated the section. Its validity score was 0.78.

3. Preventive behavior of health hazards from dust exposure was the dependent variable of this study, and was defined as any activity undertaken by an individual related to preventing health hazards from dust exposure, including dust hazard surveillance. For example, obtaining news about the dust situation, personal hygiene, early signs of over - exposure, respiratory protective devices, and monitoring and early detection of health impairment resulting from dust exposure. The variable was assessed using 20 items on the questionnaire, which were related to the previous month's history of preventive behaviors towards dust exposure. The scoring for the questionnaire was based on the frequency of preventive practice in 1 week: never done (0) to done every day (4), with a five-point numeric rating scale. Possible scores ranged between 0 - 80 points, and were divided into two categories: low to moderate (0 – 63) and high (≥ 64). Then, three experts validated the section. Its validity score was 0.79. Its reliability was tested among 30 respondents from a different area to the study sites (Cronbach α = 0.88).

Data collection

Data were collected using the questionnaire, by six research assistants with bachelor's degrees in public health. All were trained in using the research tool to read the questions and provide advice to assist participants in answering questions if the participant had doubts. Researchers made an appointment to collect data at the participants' homes during a convenient time for the respondent. The time required to answer the questionnaire was 30 - 45 minutes per participant, and they answered the questions themselves. Data were collected from April to May 2021, which is the time when sugarcane is harvested for delivery to the factory[21].

Statistical analysis

Statistical Package for the Social Sciences (SPSS) software version 28.0 was used for data analysis. Characteristics data were presented with descriptive statistics, including frequency, percentage, mean, and standard deviation (SD). Pearson's correlation and Spearman rank order correlations were used to test the correlations between the independent variables and preventive behaviors ($p < 0.05$). Stepwise multiple regression analysis was used to identify the independent variables that were most closely associated with preventive behaviors of health hazards from dust exposure (dependent variable).

Results

Data collection

Most of the respondents were female (68.2%). The mean age of respondents was 67.56 years (SD 5.59). Most of them were farmers (88.6%). 92.1% of them had an educational background of primary education. 16.1% reported having hypertension, and 12.1% had more than one disease. 81.4% had been living in the area since they were born, and the mean length of residence was 35.94 years (SD 12.90). The homes surrounding environment analysis found that most of the respondents (73.2%) whose houses were next to roads were exposed to dust from soil diffusion due to traffic. In addition, there was exposure to car exhaust (89.3%), dust from construction near the house (65.7%), and pollution from charcoal stove usage for cooking or grilling (95.7%). When going outside, 65.4% of respondents reported having symptoms, such as a stuffy nose, itchy eyes, itchy skin, and rash.

Preventive behaviors of health hazards from dust exposure

Respondents had experience with dust exposure from agricultural burning (56.1%), garbage and leaf litter burning (53.9%), and industrial factories (52.5%). Most of them used cloth or a mask to cover their nose and mouth to protect themselves from dust hazards (49.6%). 84.3% of the participants received information on preventative measures from dust exposure from public healthcare officials. 87.5% had knowledge of dust prevention practices at a high level. Additionally, 54.3% had low and moderate levels of dust prevention practices (Table 1).

Table 1 Preventive behaviors of health hazards from dust exposure (n = 280)

Preventive behaviors of health hazards from dust exposure	n (%)
Experiencing dust exposure	
Industrial factories	
No	133 (47.5)
Yes	147 (52.5)
Agricultural burning	
No	123 (43.9)
Yes	157 (56.1)
Garbage or leaf litter burning	
No	129 (46.1)
Yes	151 (53.9)
Protective behaviors of dust exposure	
None	8 (2.9)
Stay at home to avoid dust exposure	34 (2.1)
Using a cloth or a mask to cover nose and mouth	139 (49.6)
Turning on a fan for air circulation	6 (2.1)
Opening windows for air circulation	12 (4.3)
Using several preventative measures together	81 (28.9)
Source of health information (multiple responses)	
Public healthcare officials	236 (84.3)
Television/ village radio broadcast	154 (51.8)
Family members	68 (24.3)
Internet/ application	17 (6.1)
Newspaper/ leaflets/ posters	4 (1.4)
Knowledge of preventive behaviors from dust hazards	
High	245 (87.5)
Low to moderate	35 (12.5)
Mean ± SD: 8.7 ± 1.06	
Preventive behaviors of health hazards from dust exposure	
High	128 (45.7)
Low to Moderate	152 (54.3)
Mean ± SD: 61.9 ± 0.67	

SD, standard deviation

Factors predictive of preventive behaviors of health hazards from dust exposure

Stepwise multiple regression analysis revealed that four factors were predictive of preventive behaviors of health hazards from dust exposure. Those four factors were the experience of dust exposure from factories, knowledge of preventing health risks from dust exposure, getting advice from public health officials, and length of stay in the area. These factors could predict preventive behaviors of health hazards from dust exposure among the elderly with a multiple correlation coefficient of 0.39, and a predictive power of 15.0% at a statistically significant level of 0.05.

The interpretation of statistical data indicated that a high level of experience of dust exposure from factories, knowledge, and advice from public healthcare officials on preventing health hazards from dust exposure led to a high level of preventive behaviors of health risks from dust exposure among the elderly. Furthermore, a longer period of residence in the area may reduce preventive behaviors of health hazards from dust exposure among the elderly (Table 2).

Table 2 Factors predictive of preventive behaviors of health hazards from dust exposure using stepwise multiple regression analysis (n = 280)

Variable	b	SE(b)	β_{std}	*p*
Experiencing dust exposure from factories	4.01	0.26	0.88	< 0.001
Preventive knowledge of health hazards from dust exposure	2.35	0.22	0.62	< 0.001
Source of health information from public healthcare officials	3.62	0.15	1.32	0.006
Length of stay in the area (years)	-3.40	-0.11	1.67	0.043
Constant	39.55			< 0.001

SE, standard error; R^2 = 0.15, adjust R^2 = 0.14, SEE = 10.84, overall $p < 0.001$

Discussion

Elderly people in the semi-urban community exhibited preventive behaviors, such as monitoring their health and avoiding dust exposure to prevent health hazards from dust exposure. When assessing the frequency of the average weekly practice, most of them showed a low to moderate level of practices to prevent health risks from dust exposure. This may make them vulnerable to health hazards from dust exposure. These results correspond with a study by Rodsawas et al[29] which found that the health-protective behaviors among the population from PM2.5 were moderate.

The homes surrounding environment analysis found that elderly people are more prone to exposure to dust from various sources. Most households were on a roadside where cars were traveling, causing the spread of dust, as well as vehicle exhaust from cargo trucks traveling from construction sites. These results correspond with a study by Vardoulakis et al[30] which found that outdoor air is a primary PM2.5 source among roadside households. A home's location at high-traffic-density roads contributes to high indoor air pollution. Also, there is agricultural burning of materials such as rice stubble, sugarcane, garbage, and leaf litter, as well as factory smoke. About half of the elderly respondents experienced exposure from this dust and pollution. These results correspond with a study from the Chulabhorn Research Institute[31] which found that the upper northeastern region, including Sakon Nakhon province, will experience some crisis situations related to dust exposure from the burning of agricultural scraps such as rice, corn, and sugar cane.

Smoke from traffic and transport vehicles occurs in major cities from around January-May. This exhaust is a source of dust, and is one of the factors that cause particulate pollution that affects people's health and the environment. In addition, almost all the semi-urban elderly communities cook by using charcoal stoves. These results correspond to a study from U-Kong[32], which found that charcoal stoves are the main equipment that the Northeastern (Isan) people use for cooking due to their lower price and high heat efficiency. It is also traditional to Isan kitchen culture. Each household had 2 - 3 charcoal stoves, which contributed to dust inside the house. Charcoal grilling produces lots of air pollutants, most of which are PM2.5 and harmful to health[33]. In semi-urban communities, elderly people are thus at risk from exposure to dust pollutants both inside and outside the home.

Moreover, our results found that during the past 1 month, when the elderly participants went outside, they experienced symptoms such as stuffy nose, itchy eyes, itchy skin, and rashes, as some did not protect themselves from dust exposure and did not wear a mask to protect themselves from dust. These results are in line with a study by Kanyamun et al[34] which found that many elderly people do not wear a mask, as they find it uncomfortable and hard to breathe when wearing one. The results also showed that the reasons for not wearing a mask include being perceived as a sick person and having difficulty communicating, as people cannot hear them properly when they are wearing a mask.

Key findings of this study identified factors that are predictive of preventive behaviors of health hazards from dust among elderly people in a semi-urban community. There was a 15.0% variability in the preventive behaviors of health hazards from dust. The best predictor of preventive behaviors in the elderly was experience of dust exposure from factories[5-6,8,35]. The results indicated that knowledge and information on preventive behaviors received from public healthcare officials were predictive factors. The results also showed that a high level of knowledge, and advice from public healthcare officials on preventing health risks from dust exposure, were related to a high level of preventive behaviors of health risks from dust exposure. It can be assumed that most elderly will eventually develop a high level of dust protection knowledge because Thailand plans to reform the country in terms of public health to create a health literate society. Therefore, the health promotion system, including environmental health, should focus on educating people of all age groups to be able to take care of their own health. Knowledge and perception of dust exposure information was found to be related to the participation of the people in preventing health hazards from dust exposure in the community[13,36]. Most of the elderly respondents had received information and knowledge about the impact and prevention of dust exposure from public health officials, news from television, and a village news tower. These results add to a study from Rodsawas et al[29] which found that information sources such as friends or acquaintances are also important channels for people aged 60 years and over. In urban areas, most people have access to educational and information resources such as Facebook and agency websites[35].

According to the research results, although most of the elderly respondents had a high level of knowledge, the least correctly answered questions were: the wearing of a mask to reduce the amount of dust, and the avoidance of outdoor activities while the dust level exceeds the air quality index (AQI) value of 50 $\mu g/m^3$ (AQI category is moderate)[10] to decrease the chance of getting sick. This was consistent with the practical results of preventing health risks from exposure to dust, which indicated that elderly people had the least practice in refraining from exercising and working outdoors, and reducing dust-causing activities, such as burning incense, leaf litter and garbage and cooking by grilling outside. Elderly people should thus be encouraged to know more about the sources of dust and the importance of avoiding activities that lead to dust exposure, and to learn ways to prevent health risks from dust exposure. This will further help them to prevent health risks from exposure to dust.

Length of stay in the area was another factor that increases the risk of people being exposed to dust and is associated with an increase in the hazard of admissions[13,37]. The study results concerning length of stay in the area found that elderly respondents who had lived in the area for long periods of time may have compromised the practice of preventive behaviors from dust exposure. This is because most of them had lived in this area since birth, with an average length of stay of 35.9 years, and they had practiced traditional behaviors before the semi-urban community was developed into an industrial area. Back then, there were no factories, and there were few motorized vehicles. Therefore, there was no need to wear dust protection equipment. Their past behaviors have affected their current behaviors, because of this. Therefore, it will take a long time to implement a change in old behaviors to new behaviors for preventing health hazards from dust exposure among this age group. Any advice given, therefore, should be simple guidelines that suit the context of the lifestyles of elderly people[16,18,38].

A limitation of this study was its relatively small sample size. However, it provides vital information on the factors that are predictors for preventive behaviors of health hazards from dust exposure.

Conclusion

The researchers found that the predictors for preventive behaviors of health hazards from dust exposure were: experiencing dust exposure from factories, preventive knowledge of health hazards from dust exposure, health information from public healthcare officials, and length of stay in the area. Therefore, public health officials should focus on advising elderly people who have lived in the area for a long time, in order to change their health behaviors to prevent health risks from dust exposure. Future studies should monitor the health status of elderly people in semi-urban communities to prevent the long-term effects of dust. Advice on health behaviors given by healthcare providers should be simple and easy to understand for implementation that fits into a health care routine.

Author Contributions

ST, WK, NW and JC designed the study and formulated the content of the questionnaire. JC, NW and NI designed the questionnaire, with guidance from ST and WK. ST, WT, and PP conducted the study under the supervision of ST and WK. ST, PP and NI carried out reliability testing and the initial statistical analysis of data. ST re-analyzed the data and wrote the manuscript. ST produced the original English translation of the manuscript, and NI, JC and NT helped to revise it. All authors read and approved the manuscript prior to submission for publication.

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Conflicts of Interest

The authors declare that they have no conflicts of interest.

References

1. Pollution Control Department. Thailand state of pollution 2020. Vol. 26. Available from: https://www.pcd.go.th, accessed 2 December, 2021. (In Thai)
2. Chiangthong J. Rural society in the modern world. Available from: https://www.lib.ku.ac.th/web/index.php/th, accessed 2 December, 2021. (In Thai)
3. Nikam J, Archer D, Nopsert C. Air quality in Thailand understanding the regulatory context. Stockholm; 2021.
4. Hemanil S, Pongsawalee N. Community market in semi-urban area: A case study of livelihoods of northeastern Thai residents in Udon Thani province. Sunit Hemanil Mekong Chi Mun Art and Culture Journal 2018; 4(2):181–216. (In Thai)
5. Kumharn W, Sudhibrabha S, Hanprasert K. Aerosol optical depth: A study using Thailand based brewer spectrophotometers. Astron Astrophys 2015; 56(11): 2384–8.
6. Kumharn W, Janjai S, Irie H, Pilahome O. Aerosol size distribution using Thailand ground-based instruments and climate variables. Theor Appl Climatol 2020; 142(1–2): 599–611.
7. Li R, Hou J, Tu R, Liu X, Zuo T, Dong X, et al. Associations of mixture of air pollutants with estimated 10-year atherosclerotic cardiovascular disease risk modified by socio-economic status: The Henan Rural Cohort Study. Sci Total Environ 2021; 793.
8. Liu X, Tu R, Qiao D, Niu M, Li R, Mao Z, et al. Association between long-term exposure to ambient air pollution and obesity in a Chinese rural population: The Henan Rural Cohort Study. Environ Pollut 2020; 260: 1-8.
9. World Health Organization. WHO global air quality guidelines: particulate matter (PM2.5 and PM10), ozone, nitrogen dioxide, sulfur dioxide and carbon monoxide. Available from:https://apps.who.int/iris/handle/10665/345329, accessed 15 November, 2021.
10. Pollution Control Department. Air quality index data. Available from: http://air4thai.pcd.go.th/webV2/ aqi_ info. php, accessed 2 December, 2021. (In Thai)
11. Xiong L, Li J, Xia T, Hu X, Wang Y, Sun M, et al. Ris reduction behaviors regarding PM 2.5 exposure among outdoor exercisers in the Nanjing Metropolitan Area, China. Int J Environ Res Public Health 2018; 15(8): 1 – 13.
12. Labkum J, Siriburapiputtana J, Tongsim T. Sickness-prevention behavior of stone-crushing mill workers in Namyuen district, Ubon Ratchathani province. Journal of Science and Technology, Ubon Ratchathani University 2017; 19(1): 71–83. (In Thai)
13. Jawjit S, Pibul P, Muenrach N, Kuakul A. Risk assessment of PM10 exposure of stone crushing plant nearby and further communities in Nakhon Si Thammarat. Thai Journal of Science and Technology 2018; 19(1):71–83. (In Thai)
14. Williams AM. Understanding the micro-determinants of defensive behaviors against pollution. Ecol Econ 2019; 163: 42–51.
15 Department of Disease Control. Guideline: Health impact surveillance manual of haze problems for health personnel. Nontaburi; 2018. (In Thai)
16. Bozek A, Starczewska-Dymek L, Jarzab J. Prolonged effect of allergen sublingual immunotherapy for house dust mites in elderly patients. Ann Allergy Asthma Immunol 2017; 119(1): 77–82.
17. Ministry of Public Health. Handbook of medical and public health operations: In the case of dust with a particulate matter 2.5 microns (PM2.5). Nonthaburi; Ministry of Public Health; 2021. (In Thai)
18. Public Health England. Review of interventions to improve outdoor air quality and public health. Public Health England Publications. Available from: https://assets.publishing.service.gov.uk/government/uploads. access ed 5 October, 2021.
19. Allen RW, Barn P. Individual and household level interventions to reduce air pollution exposures and health risks: A review of the recent literature. Curr Environ Health Rep 2020; 7(4): 424–40.

20. Health Impact Assessment. Guidelines for preventive particulate matter 2.5. Department of Health, Ministry of Public Health. Available from: https : // hia. anamai. moph. go. th / th /main -php-filename-hia-surveillance-suggestion, accessed 2 December, 2021. (In Thai)
21. Food Intelligence Center. Sugar industry. Available from:http://fic.nfi.or.th/ foodsectordatabank-detail.php?id=23, accessed 15 April, 2021. (In Thai)
22. Panakobkit W, Sakunkoo P. Usage of respiratory protective equipment among sugarcane factory workers: Case study 3 Province in Northeastern. KKU Journal for Public Health Research 2019; 12(1): 7–11. (In Thai)
23. Khetjoi S, Thasa W, Raisa-nguan SK S. Impact of burning sugarcane leaves polluted PM2.5 Nai - Muang subdistrict, Wiangkao district Khonkaen province. Journal of Buddhist Education and Research 2021; 7(1): 16–25. (In Thai)
24. Le Blond JS, Woskie S, Horwell CJ, Williamson BJ. Particulate matter produced during commercial sugarcane harvesting and processing: A respiratory health hazard? Atmos Environ 2017; 149: 34–46.
25. Kaewpradit W. Sugarcane straw management to mitigate particulate matter and encourage sustainable sugarcane production. Khon Kaen Agriculture Journal 2021; 49(1): 1–11. (In Thai)
26. Phonphiboon T, Chaisawat I, Rungphisuthipong A. Disaster in the winter of particle matter (PM2.5). EAU Heritage Journal Science and Technology 2014; 8(1): 40–6. (In Thai)
27. Sakon Nakhon Provincial Public Health Office. HDC - Occupational and environmental diseases standards reporting group. Available from: https: // snk.hdc.moph.go.th/hdc/reports/page.php?cat_id, accessed 15 April, 2021. (In Thai)
28. Krejcie RV , Morgan DW. Determining sample size for research activities. Educ Psychol Meas 1970; 30: 607–10.
29. Rodsawas J, Naraweerawut K, Pongprasert W, Sidajit P. A study of risk perception and health behavior related to prevention of PM2.5 exposure among population in Bangkok Metropolitan Area. Health Impact Assessment. Available from: https: //hia.anamai.moph.go.th/th/news-anamai/205839, accessed 16 April, 2021. (In Thai)
30. Vardoulakis S, Giagloglou E, Steinle S, Davis A, Sleeuwenhoek A, Galea KS, et al. Indoor exposure to selected air pollutants in the home environment: A systematic review. In t J Environ Res Public Health 2020; 17(23): 1–24.
31. Chulabhorn Research Institute. Air quality assessments for health and environment policies in Thailand, Bangkok. Available from: https://www.pcd.go.th/publication/ 15135/, accessed 16 April, 2021. (In Thai)
32. U-Kong N. The cultural changes of traditional to modern kitchens of Kusantarat village. Journal of the Faculty of Arts, Silpakorn University 2018; 40(2): 276–97. (In Thai)
33. Tipayarom A, Thongkaew P, Santisukkasaem U. Emission factor and emission rate of PM2.5 and PM10 from charcoal food grilling. Veridian E - Journal Science and Technology Silpakorn University 2016; 3(5): 194–205. (In Thai)
34. Kanyamun P, Victory K, Busakorn TS, Muenmoolkat W, Chansereewitthaya K. Assessment of knowledge and practice of self-protective behavior from particulate matter 2.5 among the people in Koh Chang sub-district, Mae Sai district, Chiang Rai. In: 15th RSU National Graduate Research Conference 2020 p. 2903–13. (In Thai)
35. Chansri K, Klungpol R, Supapongsri T, Wisuwong N. A case study of perception and preventive behaviors of small particle among people in Victory Monument area, Bangkok. Journal of the Health Education Professional Association 2020; 35(1): 41–55. (In Thai)
36. Shi H, Fan J, Zhao D. Predicting household PM2.5-reduction behavior in Chinese urban areas: An integrative model of theory of planned behavior and norm activation theory. J Clean Prod 2017; 145: 64–73.
37. Danesh Yazdi M, Wang Y, Di Q , Zanobetti A, Schwartz J. Long-term exposure to PM2.5 and ozone and hospital admissions of Medicare participants in the Southeast USA. Environment International. Available from:https://reader.elsevier.com/reader/sd/pii/S0160412019300364, accessed 2 December, 2021.
38. Gardner B, Rebar AL. Habit formation and behavior change. In: Psychology. Oxford University Press; 2019.