CRYSTALLINE SILICA DUST AND PARTICULATE MATTER EXPOSURE WITH CLARA CELL PROTEIN 16 (CC16), HEME OXYGENASE 1 (HO-1) AND RESPIRATORY TRACT DISORDERS AMONG STONE-MORTAR WORKERS IN PHAYAO PROVINCE, THAILAND

SAKESUN THONGTIP

DOCTOR OF PHILOSOPHY
IN COMMUNITY MEDICINE

GRADUATE SCHOOL
CHIANG MAI UNIVERSITY
AUGUST 2019

CRYSTALLINE SILICA DUST AND PARTICULATE MATTER EXPOSURE WITH CLARA CELL PROTEIN 16 (CC16), HEME OXYGENASE 1 (HO-1) AND RESPIRATORY TRACT DISORDERS AMONG STONE-MORTAR WORKERS IN PHAYAO PROVINCE, THAILAND

SAKESUN THONGTIP

A THESIS SUBMITTED TO CHIANG MAI UNIVERSITY IN PARTIAL FULFILEMENT OF THE REQUIREMENTS FOR THE DEGREE OF DOCTOR OF PHILOSOPHY IN COMMUNITY MEDICINE

GRADUATE SCHOOL, CHIANG MAI UNIVERSITY
AUGUST 2019

CRYSTALLINE SILICA DUST AND PARTICULATE MATTER EXPOSURE WITH CLARA CELL PROTEIN 16 (CC16), HEME OXYGENASE 1 (HO-1) AND RESPIRATORY TRACT DISORDERS AMONG STONE-MORTAR WORKERS IN PHAYAO PROVINCE, THAILAND

SAKESUN THONGTIP

THIS THESIS HAS BEEN APPROVED TO BE A PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF

DOCTOR OF PHILOSOPHY

IN COMMUNITY MEDICINE

Examination Committee:

.... Chairman
(Assoc.Prof.Dr. Kraichat Tantrakarnapa)

..............................Member
(Assoc.Prof.Dr. Penprapa Siviroj)

..............................Member
(Assoc.Prof. Athavudh Deesomchok, M.D.)

..............................Member
(Dr. Tippawan Prapamontol)

..............................Member
(Dr. Supakit Khacha-ananda)

..............................Member
(Assoc.Prof.Dr. Ratana Sapbamrer)

Advisory Committee:

..............................Advisor
(Assoc.Prof.Dr. Penprapa Siviroj)

..............................Co-advisor
(Assoc.Prof. Athavudh Deesomchok, M.D.)

..............................Co-advisor
(Asst.Prof. Anawat Wisetborisut, M.D.)

..............................Co-advisor
(Dr. Tippawan Prapamontol)

26 August 2019

To

… ***my family, my teachers, my colleague and all involved for helping and achievements in the goals of this work and study*** *…*

ACKNOWLEDGEMENT

I would like to thank for research advisor: Assoc. Prof. Dr. Penprapa Siviroj, Advisor, Assoc. Prof. Athavudh Deesomchok, Assist. Prof. Anawat Wisetborisut and Dr. Tippawan Prapamontol for this thesis supporting and helping. I would like to express my sincere thanks to Dr. Supakit Khacha-ananda for crystalline silica dust analysis and Dr. Sawitree Nangola for serum clara cell protein 16 (CC16) and heme oxygenese (HO-1) analysis.

Special thanks also goes to all participants at Ban Sang Sub-district, Ban Sang Health Promotion Hospital, and Ban Sang Sub-district Municipality for providing general data, Phayao Hospital for providing pulmonary function tests and chest radiographs, Nopparat Rajathanee Hospital for reading chest radiograph, and Central Chest Institute of Thailand. A special thanks to everyone at the Department of Community Medicine and financially supported by the Faculty of Medicine, Chiang Mai University.

Finally, I would like to thank my family, my teachers, my colleague and all involved for helping and achievements in the goals of this work and study.

Sakesun Thongtip

หัวข้อดุษฎีนิพนธ์ การสัมผัสฝุ่นซิลิกาและฝุ่นละอองกับระดับโปรตีนของเซลล์คลารา 16 ระดับโปรตีนของฮีมออกซีจีเนส 1 และความผิดปกติของระบบทางเดินหายใจในผู้ประกอบอาชีพทำครกหิน จังหวัดพะเยา ประเทศไทย

ผู้เขียน นายเสกสรรค์ ทองติ๊บ

ปริญญา ปรัชญาดุษฎีบัณฑิต (เวชศาสตร์ชุมชน)

คณะกรรมการที่ปรึกษา

รองศาสตราจารย์ ดร. เพ็ญประภา ศิวิโรจน์	อาจารย์ที่ปรึกษาหลัก
รองศาสตราจารย์ นพ. อรรถวุฒิ ดีสมโชค	อาจารย์ที่ปรึกษาร่วม
ผู้ช่วยศาสตราจารย์ นพ.อนวัช วิเศษบริสุทธิ์	อาจารย์ที่ปรึกษาร่วม
ดร. ทิพวรรณ ประภามณฑล	อาจารย์ที่ปรึกษาร่วม

บทคัดย่อ

ฝุ่นละอองขนาดเล็กกว่า 10 ไมครอนที่มีองค์ประกอบของซิลิกา เป็นหนึ่งของสาเหตุการเจ็บป่วยและการเสียชีวิตของโรคระบบทางเดินหายใจ อาชีพทำครกหินมีกระบวนการที่ทำให้เกิดฝุ่นซิลิกา ซึ่งฝุ่นเหล่านี้เมื่อหายใจเข้าสู่ร่างกายจะนำไปสู่กระบวนการการอักเสบของปอด และเกิดโรคซิลิโคสิส ดังนั้นวัตถุประสงค์การวิจัยเพื่อศึกษาความสัมพันธ์ระหว่างความเข้มข้นของฝุ่นละอองขนาด 10 ไมครอน (PM_{10}) และฝุ่นซิลิกา กับความผิดปกติของระบบทางเดินหายใจ ระดับโปรตีนของคลารา 16 (CC16) และระดับโปรตีนของฮีมออกซีจีเนส-1 (HO-1) ในผู้ประกอบอาชีพทำครกหิน และเพื่อศึกษารับรู้ความเสี่ยง พฤติกรรมการป้องกันของฝุ่นละอองและคุณภาพชีวิตในผู้ประกอบอาชีพทำครกหิน และประชาชนที่อาศัยอยู่โดยรอบโรงงานทำครกหิน

วิธีการวิจัย: ระยะที่ 1 ใช้รูปแบบการศึกษาทางระบาดวิทยาการวิจัยเชิงวิเคราะห์แบบย้อนหลังจากผลไปหาเหตุ (retrospective cohort study) โดยศึกษาเปรียบเทียบในผู้สัมผัสและผู้ไม่ได้สัมผัส จำนวน 77 คน อายุ 18 ปี ขึ้นไปและอาศัยอยู่ในพื้นที่ตั้งแต่ 1 ปี ขึ้นไป เก็บข้อมูลโดยการสัมภาษณ์ประเมินความผิดปกติของระบบทางเดินหายใจ วัดระดับโปรตีนของคลารา 16 (CC16) และระดับโปรตีนของฮีมออกซีจีเนส-1 (HO-1) สถิติที่ใช้ในการวิจัยคือ multiple linear regression analysis ใช้อธิบายความสัมพันธ์ระหว่างตัวแปร และระยะที่ 2 ใช้รูปแบบการศึกษาทางระบาดวิทยาแบบ

ภาคตัดขวาง (a cross-sectional study) กลุ่มตัวอย่างคือ ผู้ประกอบอาชีพทำครกหิน 57 คน และประชาชนที่อาศัยอยู่โดยรอบโรงงานทำครกหิน จำนวน 325 คน เพื่อประเมินอาการของโรคระบบทางเดินหายใจ การรับรู้ความเสี่ยง พฤติกรรมการป้องกันการสัมผัสฝุ่นละออง และประชาชนที่อาศัยอยู่โดยรอบโรงงานทำครกหิน จำนวน 380 คน เพื่อประเมินคุณภาพชีวิต วิเคราะห์ข้อมูลโดยใช้ binary logistic regression analysis และ multiple linear regression analysis

ผลการวิจัย: ความเข้มข้นของฝุ่นละอองขนาดเล็กกว่า 10 ไมครอน (PM_{10}) ในผู้ประกอบอาชีพทำครกหิน (0.350±0.468 mg/m^3) มีระดับความเข้มข้นสูงกว่ากลุ่มควบคุม (0.033±0.021 mg/m^3) อย่างมีนัยสำคัญทางสถิติ (p<0.001) ความเข้มข้นของฝุ่นซิลิกาในผู้ประกอบอาชีพทำครกหิน (0.112 ± 0.100 mg/m^3) มีระดับความเข้มข้นสูงกว่ากลุ่มควบคุม (0.003±0.005 mg/m^3) อย่างมีนัยสำคัญทางสถิติ (p<0.001) โดยเฉพาะความเข้มข้นของฝุ่นซิลิกาสูงกว่าค่ามาตรฐานของ ACGIH (0.025 mg/m^3) ขนาดการรับสัมผัสรายวันเฉลี่ย (ADD) ของฝุ่นละอองขนาดเล็กกว่า 10 ไมครอน (PM_{10}) และฝุ่นซิลิกา ในผู้ประกอบอาชีพทำครกหินคือ 0.018 และ 0.005 มิลลิกรัม/กิโลกรัม/วัน ตามลำดับ ลักษณะความเสี่ยงตาม hazard quotient (HQ) ของฝุ่นละอองขนาดเล็กกว่า 10 ไมครอน (PM_{10}) และฝุ่นซิลิกา เท่ากับ 1.64 และ 1.67 ตามลำดับ ซึ่งถือว่ามีความเสี่ยงต่อสุขภาพจากการรับสัมผัสตามข้อกำหนดของ U.S. EPA และพบความผิดปกติของภาพรังสีทรวงอกในผู้ประกอบอาชีพทำครกหิน จำนวน 8 คน ซึ่งในจำนวนนี้พบว่าเป็นโรคซิลิโคสิส (Silicosis) จำนวน 3 คน

ระดับโปรตีนของคลารา 16 (CC16) ในผู้ประกอบอาชีพทำครกหินมีค่าเฉลี่ย±ส่วนเบี่ยงเบนมาตรฐานเท่ากับ 6.302±2.311 นาโนกรัม/มิลลิลิตร ต่ำกว่ากลุ่มควบคุม (12.05±2.95 นาโนกรัม/มิลลิลิตร) อย่างมีนัยสำคัญทางสถิติ (p<0.001) ในขณะที่ระดับโปรตีนของฮีมออกซีจีเนส-1 (HO-1) ในผู้ประกอบอาชีพทำครกหินมีค่าเฉลี่ย±ส่วนเบี่ยงเบนมาตรฐานสูงกว่า (51.62±46.13 นาโนกรัม/มิลลิลิตร) เมื่อเปรียบเทียบกับกลุ่มควบคุม (16.01±8.51 นาโนกรัม/มิลลิลิตร) อย่างมีนัยสำคัญทางสถิติ (p<0.001) ความเข้มข้นของฝุ่นละอองขนาดเล็กกว่า 10 ไมครอน (PM_{10}) และฝุ่นซิลิกา โดยเฉลี่ยตลอดระยะเวลา 8 ชั่วโมงการทำงาน มีความสัมพันธ์กับระดับโปรตีนของคลารา 16 (CC16) ทั้งในผู้ประกอบอาชีพทำครกหินและกลุ่มควบคุม อย่างมีนัยสำคัญทางสถิติ ด้วย multiple linear regression analysis หลังจากปรับด้วยอายุ การสูบบุหรี่ และการสวมใส่ผ้าปิดจมูกขณะทำงาน

บทสรุป: ความเข้มข้นของฝุ่นซิลิกาในผู้ประกอบอาชีพทำครกหินสูงกว่าค่ามาตรฐานของ ACGIH (0.025 mg/m^3) และมีระดับความเข้มข้นสูงกว่ากลุ่มควบคุม ส่วนโปรตีนของคลารา 16 (CC16) ในผู้ประกอบอาชีพทำครกหินมีระดับต่ำกว่ากลุ่มควบคุม ในขณะที่โปรตีนของฮีมออกซี

จีเนส-1 (HO-1) ในผู้ประกอบอาชีพทำครกหินมีระดับสูงกว่ากลุ่มควบคุม ซึ่งยืนยันด้วยความสัมพันธ์ระหว่างความเข้มข้นของฝุ่นละอองขนาดเล็กกว่า 10 ไมครอน (PM_{10}) และฝุ่นซิลิกา โดยเฉลี่ยตลอดระยะเวลา 8 ชั่วโมงการทำงาน (8-hr TWA) กับโปรตีนของคลารา 16 (CC16) ทั้งในผู้ประกอบอาชีพทำครกหินและกลุ่มควบคุม ดังนั้นโปรตีนของคลารา 16 (CC16) เป็นตัวบ่งชี้ทางชีวภาพที่จำเป็นต่อการทำนายการสัมผัสฝุ่นละอองขนาดเล็กกว่า 10 ไมครอน (PM_{10}) และฝุ่นซิลิกาของผู้ประกอบอาชีพทำครกหินได้ และควรมีการตรวจวัดฝุ่นละอองขนาดเล็กกว่า 2.5 ไมครอน ($PM_{2.5}$) เนื่องจากสามารถเข้าสู่ปอดได้โดยตรง

Dissertation Title Crystalline Silica Dust and Particulate Matter Exposure with Clara Cell Protein 16 (CC16), Heme Oxygenase 1 (HO-1) and Respiratory Tract Disorders Among Stone-Mortar Workers in Phayao Province, Thailand

Author Mr. Sakesun Thongtip

Degree Doctor of Philosophy Program (Community Medicine)

Advisory Committee	Assoc.Prof.Dr. Penprapa Siviroj	Advisor
	Assoc.Prof. Athavudh Deesomchok, M.D.	Co-advisor
	Asst.Prof. Anawat Wisetborisut, M.D.	Co-advisor
	Dr. Tippawan Prapamontol	Co-advisor

ABSTRACT

Particulate matter less than ten micrometers in diameter (PM_{10}) containing crystalline silica is the leading cause of illnesses and death of respiratory disorders. Stone-mortar process has produced PM_{10} containing crystalline silica which these dusts easily enters the lower respiratory system and interacts with pulmonary cells causing tissue reaction, inflammation, pathological changes of pulmonary fibrosis, and silicosis. Therefore, this study aimed to examine the dose-response relationship of PM_{10} and crystalline silica with respiratory disorders, clara cell protein 16 (CC16) and heme oxygenese (HO-1) levels among stone-mortar workers, and to assess the risk perception, preventive behaviors, and health related quality of life (HRQOL) among stone-mortar workers and people living around stone-mortar factories.

Methodology: First phase was a retrospective study for an exposed group and an unexposed group. Seventy-seven subjects aged over 18 years and must have lived at study areas for at least 1 year. We obtained a history of respiratory disorders, CC16 and HO-1 detection. Multiple linear regression analysis was used to examine the association between selected variables and outcomes. Second phase was a cross-sectional study which the sample sizes were 57 stone-mortar workers, 325 people living around stone-mortar factories for risk perception, and 380 people living around stone-mortar factories for HRQOL. Binary logistic regression analysis and multiple linear regression analysis were used to examine the association between selected variables and outcomes.

Results: The mean±SD of PM_{10} concentration in stone-mortar workers (0.350±0.468 mg/m^3) was significantly higher than those in control group (0.033±0.021 mg/m^3) (p<0.001). The mean±SD of crystalline silica concentration in stone-mortar workers was 0.112 ± 0.100 mg/m^3 which was significantly higher than those in control group (0.003 ± 0.005 mg/m^3) (p<0.001). Especially, crystalline silica exceeded the standard level of ACGIH (0.025 mg/m^3). The average daily doses (ADD) of PM_{10} and crystalline silica in the stone-mortar workers were 0.018 and 0.005 mg/kg-day, respectively. Risk characterization with a hazard quotient (HQ) of PM_{10} and crystalline silica were 1.64 and 1.67, respectively which were considered risk health effects from exposure following by the U.S. Environmental Protection Agency (US EPA). Eight stone-mortar workers had abnormal chest radiographs; three workers had silicosis. The mean±SD of serum CC16 level in stone-mortar workers was 6.30±2.31 ng/ml, which was significantly lower than those in control group, 12.05±2.95 ng/ml (p<0.001). On the contrary, there was a significantly higher level of serum HO-1 in the stone-mortar workers group (51.62±46.13 ng/ml) compared with those in the control group (16.01±8.51 ng/ml) (p<0.001). An eight-hour TWA of PM_{10} and crystalline silica concentration were associated with serum CC16 levels using multiple regression analysis after adjusting for age, current smoker, wearing a mask while working.

Conclusions: The concentration of crystalline silica exceeded the standard level of ACGIH (0.025 mg/m^3) and was higher than those in control group. The serum CC16 level in stone-mortar workers was lower than those in control group while serum HO-1 level in the stone-mortar workers group was higher than those in the control group. Our study confirmed that an eight-hour TWA concentrations of PM_{10} and crystalline silica were significantly associated with serum CC16 level in stone-mortar worker and control groups. Thus, our data provide evidence that CC16 may be a potential biomarker to predict the exposure of PM_{10} and crystalline silica among stone-mortar workers. In addition, further study directly assessing $PM_{2.5}$ due to penetrate deeply into the lung.

CONTENTS

Page

Page

Page

Page

LIST OF TABLES

Page

Page

LIST OF FIGURES

LIST OF ABBREVIATIONS

ACGIH	Association Advancing Occupational and Environmental Health
Al	Aluminium
ANOVA	Analysis of Variance
AT	Average Time
ATS	American Thoracic Society
ATS-DLD	American Thoracic Society Division of Lung Diseases
AQP	Air Quality Perception
ADD	Average Daily Dose
BMI	Body Mass Index
BP	Bodily Pain
BW	Body Weight
C	Contaminant concentration in Air
CC16	Clara cell protein 16
CI	Confidence Interval
Cl	Chlorine
COPD	Chronic obstructive pulmonary disease
DNA	Deoxyribonucleic Acid
ED	Exposure Duration
EDS	Energy Dispersive X-Ray Spectroscopy
EF	Exposure Frequency
ELISA	Enzyme-Linked Immunosorbent Assay
ET	Exposure Time
Fe	Iron
$FEF_{25-75\%}$	Forced expiration flow rate at 25-75% of forced viral capacity
FEV_1	Forced Expiratory Volume in one second
FVC	Forced Vital Capacity
FEV_1/FVC	Forced Expiratory Volume in one second/Forced Vital Capacity
FINJEM	Finnish job-exposure matrix
GH	General Health

GIS	Geographic Information System
GPS	Global Positioning System
HO-1	Heme Oxygenase-1
HRQOL	Health Related Quality of Life
HQ	Hazard Quotient
IARC	International Agency for Research on Cancer
ILO	International Labour Organization
IR	Inhalation Rate
IQOLA	International quality of life assessment
JEM	Job Exposure Matrix
MCS	Mental Component Summary
MH	Mental health
Mg	Magnesium
MMAD	Mass median aerodynamic diameter
Na	Sodium
ND	Not Determined
NIOSH	National Institute of Occupational Safety and Health
OSHA	Occupational Safety and Health Administration
OR	Odds Ratio
PCS	Physical Component Summary
PEL	Permissible Exposure Limit
PF	Physical Functioning
$PM_{2.5}$	Particulate matter less than two point five micrometers in diameter
PM_{10}	Particulate matter less than ten micrometers in diameter
PPE	Personal Protective Equipment
PVC	Polyvinyl Chloride
QGIS	Quantum Geographic Information System
RE	Role Limitations due to Emotional Problems
RfD	Reference Dose
ROS	Reactive Oxygen Species
RP	Role Limitations due to Physical Problems

SD	Standard Deviation
SEM	Scanning Electron Microscopy
SF	Social Functioning
SF-36	36-Item Short Form
Si	Silicon
SiO_2	Silicon Dioxide
SMW	Stone-Mortar Workers
SOD	Superoxide dismutase
TEM	Task Exposure Matrix
TSP	Total Suspended Particulate
TWA	Time Weighted Average
US.EPA	United States Environmental Protection Agency
VT	Vitality
WHO	World Health Organization
WHOQOL	World Health Organization Quality of Life

ข้อความแห่งการริเริ่ม

1) กระบวนการทำครกหินก่อให้เกิดฝุ่นละอองขนาดเล็กกว่า 10 ไมครอน (PM_{10}) และฝุ่นซิลิกา ซึ่งฝุ่นซิลิกาเกินค่ามาตรฐานของ ACGIH ทำให้มีผลกระทบต่อความผิดปกติของระบบทางเดินหายใจของผู้สัมผัสโดยตรง และผู้ที่อาศัยโดยรอบโรงงานผลิตครกหิน

2) การเฝ้าระวังฝุ่นซิลิกาในกลุ่มผู้ประกอบอาชีพเกี่ยวข้องฝุ่นหิน ควรมีความตระหนักและตรวจอาการและอาการแสดงของโรคระบบทางเดินหายใจ ตรวจวัดสมรรถภาพปอด เอกซเรย์ปอดเป็นระยะๆ อย่างสม่ำเสมอ นอกเหนือจากการลดการสัมผัสฝุ่นดังกล่าว ควรทำการตรวจวิเคราะห์ตัวบ่งชี้ทางชีวภาพที่จำเป็น (Potential biomarkers) ในการวินิจฉัยการอักเสบของปอดในระยะแรก เพื่อบ่งชี้ก่อนเกิดโรคซิลิโคสิส

STATEMENTS OF ORIGINALITY

1) Stone-mortar process has produced particulate matter less than ten micrometers in diameter (PM_{10}) and crystalline silica which crystalline silica exceeded the standard level of ACGIH. These dusts can affect respiratory tract system to human health of stone-mortar workers and the people living around stone-mortar factories.

2) Exposure surveillance to crystalline silica associated with stone workers. Stone workers should be examined periodically to check for signs and symptoms of respiratory diseases, pulmonary function, and chest radiographs. In addition to the reduction of dust concentration, it also should conduct an analysis of some potential biomarkers which should be used in diagnose the lung inflammation at early stage to indicate silicosis.

CHAPTER 1

INTRODUCTION

1.1 Background

Air pollution is an aggravating global environmental problem especially the presence of particulate matter less than ten micrometers in diameter (PM_{10}) which is a complex mixture of extremely small particles and liquid particles suspended in air. Most particles are the result of complex interactions of chemicals which are emitted from both natural and anthropogenic sources [1]. However, particles are largely attributable to human activity [2]. In addition, the level of particles in occupational working or living environments can affect health problems for both occupational workers and people living in the vinicity of air pollution sources [3,4]. Particularly, the PM_{10} containing crystalline silica originated from activities related to construction, glass products, pottery products, construction stone, masonry and stone products invariably contain respirable crystalline silica [5-7]. The different types of particulate matter may be divided into three categories: particles which are 2.5 to 10 micrometres in diameter are called coarse particles and the most common usually can enter the upper respiratory tract. Particles which are 0.5 to 2.5 micrometres in diameter usually can enter the bronchial tree and air sacs (alveoli) of lung. Particles which are less than 0.5 micrometres in diameter may be filtered out by its cilia and dislodged by breathing (eg. coughing) [8,9]. Especially, PM_{10} containing crystalline silica (aerodynamic diameter less than ten micrometers) occurs in many industries and occupations can enter a nose, throat, and lungs by breathing. Particles which are usually enter into the bronchial tree and response to lung tissue reducing efficiency of the immune system air sacs (alveoli) of lung [7].

Moreover, the International Agency for Research on Cancer (IARC) classified crystalline silica as a Group 1 human carcinogen in 1997 [10-12]. Therefore, the Joint International Labour Organization (ILO) and World Health Organization (WHO) committee on occupational health have established the ILO/WHO global programme for the elimination of silicosis in 1995 and the prevention campaign to eliminate silicosis from the world by 2030 [13].

Mechanism of entering the body of crystalline silica dust by inhalation of small particle with crystalline silica or silicon dioxide which these particles can penetrate the lower respiratory system and the accumulation of dust in the lungs. When small particles can enter the human body and affect the lung and tissue lung, those particles ingested by macrophages in the air sacs. Crystalline silica has the sharpness of the crystal. Therefore, Macrophages are broken and eventually decay. Fibrin releases the enzyme to stimulate the fibroblast in the lungs with the release of crystalline silica. Other macrophages will also be ingested [14,15].

The different types of silicosis may be divided into three categories: Chronic silicosis occurs in people who have been exposed to crystalline silica dust for 10 years. The pathogenesis of chronic silicosis is gradual, with the formation of a nodule after long exposure, with fatigue, and cough with phlegm. Accelerated silicosis occurs in people who have been exposed to crystalline silica dust for 5-10 years. Chronic cough and exertional dyspnea (shortness of breath) are common findings. Acute silicosis occurs in people who have been exposed to crystalline silica dust for a few weeks to 5 years, with dust containing crystalline silica at high concentration. The pathogenesis of chronic silicosis is gradual, with the formation of a nodule after long exposure, with fatigue, and cough with phlegm. Symptoms of silicosis can appear from 1-2 weeks after exposure to silica dust. The patient is more likely to have difficulty breathing, followed by dry cough, chest pain, dyspnea, weight loss, and cardiovascular failure [7,16].

The diagnostic criteria of occupational diseases commemorative edition on the auspicious occasion of His Majesty the King’s 80th Birthday Anniversary in 2007 for pneumoconioses and silicosis included 3 criteria as follows [17]: 1) The patient's occupational history has been exposed to the stone mineral dusts for at least 2 years, 2) From the chest radiograph, the patient has some abnormality from profusion of 1/1 following the guidelines for the use of the ILO International Classification of Radiographs of Pneumoconioses and 3) Having sign of pathology of lung biopsy or epidemic evidence to support.

Moreover, basing on literature and research review concerning the exposed workers in crystalline silica in the Asia-Pacific region and the global which found health problems such as respiratory symptoms, pulmonary function, chest radiograph, and inflammatory biomarkers as following these situations. The situation of respiratory symptoms, we found that about one-third (32.7%) of the sandstone quarry workers attributed cough with breathing difficulties as the most important symptom of silicosis. But some of the respondents also mentioned fever for more than 15 days (20.5%), fever with loss of weight (20.7%) or weakness, loss of appetite and fever in the evening (12.2%) as main symptoms of silicosis in 2011 in Desert Ecology of Jodhpur, Rajasthan, India [18]. There were 20 workers (11.7%), which had symptoms consistent with chronic bronchitis and 8 workers (4.7%) showed asthma and asthma-like symptoms among agate grinding workers in Iran in 2014 [19]. The prevalence of chronic cough (26.6%), wheeze (24.7%), asthma (17.3%), pneumonia (17.1%), chronic bronchitis (13.4%), and emphysema (5.6%) in the exposed communities was higher than that of the unexposed communities around mine dumps in Gauteng and North West Province, in South Africa, 2015 [20]. The prevalence of respiratory symptoms among brick field workers of West Bengal, India in 2015 dyspnea was 46.8%, phlegm was 39.2%, and chest tightness was 27.6% [21]. Twenty-five percent of automotive part foundry workers in 2014 reported multiple respiratory symptoms including coughing, phlegm, wheezing and shortness of breath whereas 35% had single symptom including cough, phlegm and shortness of breath [22].

The situation of pulmonary function, we found that significant associations of exposure to concrete dust with a small pulmonary function loss were found in a cement factory of year 2001 in the Netherlands [23]. Exposed workers compared to the unexposed group showed significant reduction in forced expiratory volume in one second (FEV_1), forced vital capacity (FVC), and forced expiratory flow at 25-75% of FVC ($FEF_{25-75\%}$) (p<0.05) at a cement factory in the east of Iran in 2012 [24]. The most frequent disorder observed in spirometry was the restrictive pattern (n=43, 30%) among agate grinding workers in Iran in 2014 [19]. There was significantly lower (p<0.001) in pulmonary function when compared with control group in among brick field workers, West Bengal, India in 2015 [21]. The situation of pulmonary function in Thailand, we found that the correlation between serum HO-1 levels and percentage of Force expiratory volume in one second forced vital capacity (FEV_1/FVC) was negative significance (r=-0.219, p<0.01) among the stone mill workers, Northern Thailand in 2012 [25]. Pulmonary function test indicated that 24 percent of the workers had mild restrictive lungs (decreased FVC, FEV_1, $FEF_{25-75\%}$). coughing, phlegm and shortness of breath were significantly associated with reduced pulmonary function (p=0.001, 0.034 and 0.024, respectively) among automotive part foundry workers in 2014 [22]. From the situation of chest radiograph finding diagnosed with silicosis, we found that 1,437 decedents had silicosis as death or the underlying cause which were aged 15-44 years and the most of 1,370 males (95.3%) between 2001 and 2010 in the United States [26].

The prevalence of silicosis was 12.9%; 18 workers had simple and 4 had complicated silicosis among agate workers in Iran. There was a significant (p<0.05) association of contracting silicosis and exposure duration in 2014 [19]. There were incident silicosis 203 cases (23.28%) from the high risk group and 4 cases (0.46%) from the low risk group in china, 2015 [27]. Moreover, the situation of silicosis in Thailand, we found the incidence of silicosis that were found to be 9% of workers in stone grinding factories in Saraburi, Thailand and had radiologic evidence of silicosis in 1995 [28]. The incidence of silicosis was 10.34% in stone crushing workers, followed by 9.68% in quarrying commnuities, and 3.48% in in quarrying workers in 2009 [29]. Limestone crusher factories were 4 silicosis-suspected subjects in 2014 [30]. A study among stone-mortar and pestle workers in Thailand reported 19 subjects with silicosis in 2014 [31]. In stone carving workers, the prevalence of radiographic change was 8.9% (68 subjects). There were 66 subjects with parenchymal lesions and profusion (>grade 1/0 as for the ILO classification). Two subjects have pleural abnormalities. Interestingly, 55 cases (68%) with radiographic abnormalities were compatible with tuberculosis; 32% of whom showed no clinical evidence of tuberculosis in 2014 [32].

More recently, silicosis was reported to occur in 36.1% among Thai stone carvers in 2017 [33].

In the present, medical histories and radiological findings have been used to diagnose silicosis. However, these findings were significantly found in the late stages of the disease. Moreover, there is no effectively treatment for silicosis. Consequently, an early diagnosis or prediction by biological markers might become very beneficial to screen and monitor the disease before it is diagnosed by conventional approaches [15,34-36]. A previous finding revealed that serum clara cell protein 16 (CC16) and heme oxygenase-1 (HO-1), which serve as antioxidative, antiapoptotic and anti-inflammatory activities in the lung lining fluid, were correlated with crystalline silica exposure in the respiratory tract system as described elsewhere. Serum CC16 and HO-1 could be detected in the lung tissue after PM_{10} and crystalline silica exposed. There found that the high concentration of PM_{10} and crystalline silica affects the lungs by damaging the lining of the lung air sacs and lead to deterioration in functional performance. Many researchers suggested that this protein helped prevent reactive oxygen species (ROS) inducing airway inflammation from crystalline silica exposure, which has a key role in the development of silicosis [34,37-41]. In addition, there were associations of CC16 and HO-1 concentrations with declining pulmonary function. Long-term and short-term exposure to high concentration of PM_{10} and crystalline silica may compromise the integrity of the lung epithelium and lead to increased epithelial barrier permeability in the lungs [41,42].

According to previous studies, PM_{10} and crystalline silica dust in working areas and environment have been found to be associated with respiratory symptoms, pulmonary function disorders, and silicosis [18-21,23]. Moreover, it is necessary to find out the risk perception, preventive behavior and quality of life in order to the level of risk perception has affects to change in self-protective behavior to avoid health risks. Thus, the high level of self-protective behavior for crystalline silica exposure can help to make better quality of life in both occupational workers and people living near the sources as following risk perception and health related quality of life (HRQOL) concepts [43-46].

In addition, it is imperative to find out whether or not people living in the vinicity of stone mortar factories have risk perception as well as health risks awareness. Frequent or prolonged exposure to crystalline silica often occurs as part of working or living near the stone-mortar factories but many exposed persons might not be aware of the potential health hazards from working and living in their familiar environment [47-49]. The lack of awareness or the low level of perception means the low likelihood for the individual to behave in self protective ways to avoid the harm from air pollution [50,51]. Health is one of the most important aspects of their HRQOL which HRQOL measurement are particularly important for health determinant indicators. Health and HRQOL outcomes are used to evaluate the stone-mortar workers and communities. Previous studies found that characterization of greater socio-economic disadvantage, riskier health behaviors, and environmental degradation that were associated with reduced HRQOL [52].

Stone-mortar process has used granite and sand stone for raw materials which each process had generated PM_{10} containing crystalline silica by cutting and grinding machine. Stone-mortar workers lived in Ban Sang Sub-district, Phayao Province, had 2 villages, namely, Village 6 - Ngio Nuea Village and Village 7 - Ngio Tai Village. Most of the raw materials were granite and sand stone from Chiang Rai Province and Phayao Province.

Stone-mortar production has been an informal labor intensive cottage industry for a long time and PM_{10} containing crystalline silica from stone-mortar production contains the harmful inhalable crystalline silica which can penetrate deep into the respiratory tract system and cause such occupational lung disease as silicosis [10-12]. There were many stone-mortar workers infected by silicosis in 1972. Sixty-one stone-mortar workers (9.0%) infected by silicosis, 13 of them (1.9%) infected by tuberculosis in 1995 and one with tuberculosis and one with asthma in 2010. There were 3 invididuals with lung cancer and one with asthma in 2011, one with brain cancer and lung cancer, one with asthma in 2013 and one with lung cancer in Phayao Province in 2014 [53]. In entering the area to carry out a pilot study and interview with Municipal president of Ban Sang Sub-district, it was found that the stone-mortar making had been done for 200 years. There were died from stone-mortar making every year. In addition, researcher have been analysed the components of dust sample from polyvinyl chloride (PVC) filter using scanning electron microscopy (SEM) and energy dispersive X-ray spectroscopy (EDS). The results of the chemical components of dust were found silicon (Si), aluminium (Al), chlorine (Cl), iron (Fe), sodium (Na), and magnesium (Mg).

1.2 Rationale

Stone-mortar process has produced PM_{10} containing crystalline silica which dust can enter the lung's deep airways through respiratory tract system after that affects the lungs by damaging the lining of the lung air sacs and the air sacs in the lungs (alveoli) are damaged. PM_{10} containing crystalline silica has free radical and ROS activity which can cause epithelial damage and pulmonary inflammation. These dusts causing illness and premature death of respiratory disease, respiratory symptom disorders, decrease pulmonary function and silicosis which those who often had exposed PM_{10} containing crystalline silica in their working areas. Interestingly, serum CC16 and HO-1 could be detected in the lung tissue after exposure to PM_{10} and crystalline. These would be affected on their health from the familiar environment making them non-aware of it.

Most importantly, stone-mortar worker had exposed PM_{10} and crystalline silica in working areas for a long time and duration of exposure which found that stone-mortar workers had health problems such as respiratory symptoms, pulmonary function impairment, chest radiograph, and respiratory tract inflammatory. Moreover, the dose-response assessment is the process of the risk assessment process quantitates the hazards of what is relationship between the magnitude of dose and the response. Thus, there is relationship between the dose of PM_{10} and crystalline silica and respiratory disorders. These results could be used to identify the standard value for exposure to PM_{10} and crystalline silica and respiratory disorders in stone-mortar workers.

Moreover, the level of risk perception has affected on their behavioral change to prevent the danger of their health and has better HRQOL. Besides, those with high awareness on the health risk have better behavior in attempting to prevent themselves from the air pollution than those with low awareness. It was also found that the concentration of PM_{10} and crystalline silica cause the danger or inconvenience affecting physical health and mental health of the individuals who had exposed in working area and people living around the air pollution source. It had become the risk factors on perception, emotion, thought, and behavior, and served as a significant indicator of HRQOL.

1.3 Purposes of the study

Our study aimed to identify and examine as follow:

1.3.1 The exposure concentrations of PM_{10} and crystalline silica among stone-mortar workers.

1.3.2 The health outcomes on the respiratory symptoms, pulmonary function, chest radiographs and biomarkers among stone-mortar workers and people living around stone-mortar factories.

1.3.3 The dose-response relationship between PM_{10} and crystalline silica with respiratory disorders, CC16 and HO-1 levels among stone-mortar workers.

1.3.4 The risk perception and preventive behaviors of crystalline silica dust exposure, and HRQOL in stone-mortar workers and people living around stone-mortar factories.

1.4 Literature review

1.4.1 Situation of an occupational lung diseases

Occupational lung diseases resulted from maintaining occupation at risk of breathing in dust, smoke, or poison in lung while working. These substances could cause irritation or be left over in the breathing organ. Some could have infamed lung or fibrosis. Some may have allergic responses such as asthma. While working, it breathing in dust, inorganic substances, or mineral dusts would open for the chance of infamed lung or fibrosis causing the lung disease technically known as pneumoconiosis which is the general term for all occupational lung disease caused by silicosis and asbestosis, for example [54].

There are 3 types of crystalline silica dust that causes silicosis. They are quarts, cristobalite, and tridimite. In 1997, IARC had identified crystalline silica as quartz or or cristobalite from occupational site as cancer caused substance or technically called carcinogenic in humans (Group 1) [10,55]. Silicosis is a lung disease from the workplace or pneumoconioses resulted from breating in crystalline silica or silicon dioxide (SiO_2) into body in form of very tiny dust via breathing in to be accumulated in the lung's airbag. The dust coming in lung airbag would cause the tissue reaction causing inflammation and fibrosis pathology in the lung [10,56].

From the situation of silicosis in the Asia-Pacific region and the global, we found that 1,437 decedents had silicosis as death or the underlying cause which were aged 15-44 years and the most of 1,370 males (95.3%) between 2001 and 2010 in the United States [26]. The prevalence of silicosis among agate workers was 12.9% (95% confidence interval (CI): 7.9%-18.0%); 18 workers had simple and 4 workers had complicated silicosis. There was a significant ($p<0.05$) relationship between contracting silicosis and exposure duration in Iran in 2014 [19]. There were 203 incident silicosis cases (23.28%) from the high risk group (risk score≥5.91) and 4 cases (0.46%) from the low risk group (risk score<3.97) in China in 2015 [27]. Moreover, from the situation of silicosis in Thailand, we found the incidence of silicosis that were found to be 9% of workers in stone grinding factories in Saraburi, Thailand and had radiologic evidence of silicosis in 1995 [28]. There were 10.34% in stone crushing workers as the incidence of silicosis, followed by 9.68% in quarrying commnuities, and 3.48% in quarrying workers in 2009 [29]. There were no lung lesions in of chest radiograph in stone mill workers but the average of crystalline silica in stone mills were over the American Conference of Governmental Industrial Hygienists (ACGIH) standard (0.025 mg/m^3) in Northern Thailand in 2012 [25]. There were 4 silicosis-suspected subjects and the increased serum HO-1 level was specifically related to silica exposure and chest radiograph finding independently from age and smoking status in limestone crusher factories in 2014 [30]. A study among stone-mortar and pestle workers in Thailand reported 19 subjects with silicosis [31]. In stone carving workers, the prevalence of radiographic change was 8.9% (68 subjects) in 2014. There were 66 subjects with parenchymal lesions and profusion (>grade 1/0 as per ILO classification). Two subjects have pleural abnormalities. Importantly, 55 cases (68%) with radiographic abnormalitieswere compatible with tuberculosis; 32 of whom showed no clinical evidence of tuberculosis in 2014 [32]. More recently, silicosis was reported to occur in 36.1% among stone carvers in Thailand in 2017 [33].

Medical histories and radiological findings have been used to diagnose silicosis; however, these findings were significantly found in the late stages of the disease. Moreover, there is no effectively specific treatment for silicosis. Consequently, an early diagnosis or prediction by biological markers might become very beneficial to screen and monitor the disease before it is diagnosed by conventional approaches [34-36]. Previous studies discovered that CC16 could be detected in the lung tissue after PM_{10} and crystalline exposure. The high concentration of PM_{10} and crystalline silica affects the lungs by damaging the lining of the lung air sacs and lead to deterioration in functional performance [40,41]. In addition, there were associations of CC16 concentrations with declining pulmonary function. Long-term and short-term exposure to high concentration of PM_{10} and crystalline silica may compromise the integrity of the lung epithelium and lead to increased epithelial barrier permeability in the lungs [41,42].

The situation of respiratory symptoms in the Asia-Pacific region and the global, we found that about one-third (32.7%) of the sandstone quarry workers attributed cough with breathing difficulties as the most important symptom of silicosis. But some of the respondents also mentioned fever for more than 15 days (20.5%), fever with loss of weight (20.7%) or weakness, loss of appetite and fever in the evening (12.2%) as main symptoms of silicosis in 2011 in Desert Ecology of Jodhpur, Rajasthan, India [18]. There were 20 workers (11.7%), which had symptoms consistent with chronic bronchitis and 8 workers (4.7%) showed asthma and asthma-like symptoms in agate grinding workers in Iran, 2014 [19]. The prevalence of asthma was 17.3%, chronic bronchitis was 13.4%, chronic cough was 26.6%, emphysema was 5.6%, pneumonia was 17.1% and wheeze was 24.7% in the exposed communities was higher than that of the unexposed communities around mine dumps in Gauteng and North West Province, in South Africa in 2015 [20]. There were respiratory symptoms among brick field workers of West Bengal, India, which the prevalence of respiratory symptoms; dyspnea was 46.8%, phlegm was 39.2%, and chest tightness was 27.6% in 2015 [21]. The situation of respiratory symptoms in Thailand, we found that the prevalence of all respiratory symptoms of students in Naphralan school was statistically significant higher than students in Bankoktoom, Saraburi Province in 2006 [57]. In 2014, Twenty-five percent of the workers reported multiple respiratory symptoms including coughing, phlegm, wheezing and shortness of breath whereas 35% had single symptom including coughing, phlegm and shortness of breath among automotive part foundry workers [22].

The situation of pulmonary function in the Asia-Pacific region and the global, we found that significant associations between exposure to concrete dust and a small pulmonary function (FEV_1/FVC ratio) loss were found in concrete workers of year 2001 in Netherlands [23]. Exposed workers compared to the unexposed group showed significant reduction in FEV_1, FVC and $FEF_{25\text{-}75\%}$ ($p<0.05$) at a cement factory in the east of Iran in 2012 [24]. The most frequent disorder observed in spirometry was the restrictive pattern (n=43, 30%) in agate grinding workers in Iran in 2014 [19]. There was significantly lower ($p<0.001$) in pulmonary function when compared with control group in among brick field workers, West Bengal, India in 2015 [21]. The situation of pulmonary function in Thailand, we found that the correlation between serum HO-1 levels and crystalline silica levels was positive significance (r=0.419, $p<0.01$) whereas the correlation between serum HO-1 levels and percentage of FEV_1/FVC was negative significance (r=-0.219, $p<0.01$) in 2012 in the stone mill workers, Northern Thailand [25]. Pulmonary function test indicated that 24 percent of the workers had mild restrictive lungs (decreased FVC, FEV_1, $FEF_{25\text{-}75\%}$). coughing, phlegm and shortness of breath were significantly associated with reduced pulmonary function (p=0.001, 0.034 and 0.024, respectively) among automotive part foundry workers in 2014 [22].

1.4.2 Exposure to occupational PM_{10} containing crystalline silica

1.4.2.1 General characteristics of PM_{10} and crystalline silica

PM_{10} is a complex mixture of extremely small particles and liquid droplets that get into the air in the areas full of dust in the atmposphere. In general, there are 4 main types, namely, 1) natural particle, 2) man-made particle emerged from transportation, traffic, and construction, 3) particle emerged from industry, and, 4) particle from other activities such as cleaning, food making, painting, for example [2,58,59].

Particulate matter could be devided into 3 types as follows [60]:

1) Total suspended particulate (TSP) which is referred to particulate matter less than 100 micrometers in diameter regarded as large particle.

2) PM_{10} which is referred to particulate matter less than 10 micrometers in diameter.

3) $PM_{2.5}$ which referred to particulate matter less than two point five micrometers in diameter.

Particle size could be classified by size into 2 groups. The first one is of the particle which is too large to breath in called non-respirable particle which is referred to the particle with the size larger than 10-15 micrometers which could be screened out by nose hair and mucus to prevent it from getting down into trachea. The particle smaller than 10 micrometers is the one that could pass through lower respiratory organ. It is called resporable particle which could be further divided by its mass median aerodynamic diameter (MMAD) into 3 groups. Group 1 is of the particple with the size of 2.5-10 micrometers called coarse mode fraction which is always left over at upper and midle respiratory tracts. Group 2 is of the particple with the size of 0.5-2.5 micrometers called fine mode fraction which could fall down to be left over at small bronchial lung distal and sac. Group 3 is of the particle with the size smaller than 0.5 micrometers known as smallest particle which could be breathed in and out. Particles emerged from grinding in mining industry has the size about 3-10 micrometers or larger which is size of crystalline silica dust that could get into human body. Crystalline silica which is breathed and could endanger lung is the tiny dust that could breathed in and accumulated in lung air bags [16,61].

PM_{10} containing crystalline silica or SiO_2 as component would be found in the industrial areas of stone making, mining, brick making, stone carving, stone polishing, and stone grinding, and stone-mortar making [19,21,25,27,32]. The process of each of the production could create the dust which has silica components or SiO_2 spreading all over the working areas and surrounding communities.

From reviewing the literature and researches related to the measurement on particulate matter and crystalline silica as summarized below:

Danphaiboon et al. studied blood HO-1 levels in stone mill workers in Upper North Thailand in 2012, which crystalline silica levels were 1.30, 1.99, 6.34, 1.10, 15.08, 15.91, 6.31, 11.25 and 1.67 mg/m^3 in 9 stone mill and crystalline silica levels were over ACGIH standard (0.025 mg/m^3) using spectrophotometer [25].

Franque Mirembo et al. studied respirable quartz exposure on two medium-sized farms in southern Mozambique in 2013, which found respirable dust and quartz ranged from 0.01 to 2.88 and 0.001 to 0.30 mg/m^3, respectively [62].

Nambunmee et al. studied increased serum HO-1 in silicosis-suspected subjects in limestone crusher factories, Thailand in 2014, which crystalline silica was 0.94-27.03 mg/m^3 using spectrophotometer according to the National Institute for Occupational Safety and Health (NIOSH) Method 7601 [30].

Nambunmee et al. studied serum heme oxygenase-1 level in silicosis patients and stonemortar and pestle production workers, Thailand in 2014, which crystalline silica level was 3.97–21.12 mg/m^3 using spectrophotometer [31].

Omidianidost et al. studied assessment of occupational exposure to dust and crystalline silica in foundries in Pakdasht, Iran in 2015, which found crystalline silica ranged from 0.02 to 0.1 mg/m^3 and crystalline silica concentration was higher than NIOSH and ACGIH (0.025 mg/m^3) using the method 7601 of NIOSH. Total dust concentration average was higher than the allowed extent by Permissible Exposure Limit (PEL) of the Occupational Safety and Health Administration (OSHA) [63].

From the literature review on the measurement on PM_{10} and crystalline silica, the researcher had used the personal air sampling to measure about PM_{10} using gravimetric method according to NIOSH method 0600 and crystalline silica using spectrophotometer according to NIOSH method 7601.

1.4.2.2 Mechanism of crystalline silica on human health

1) Mechanism of silicosis

The breathed in crystalline silica could cause the danger if it is less than ten micrometers in diameter. When silica dust accessing the lung air bag, the lung tissues would be eaten up by macrophage in the lung air bag (Alveolar macrophage). Macrophage would try to eat up the silica ore. As silica crystal is sharp, it could break through the wall of lysosome in macrophage resulting the macrophage finally brokendown releasing lysosome enzymes and chemotactic factor to activate fibroblast to build up fibrin and membrane in lung along with releasing silica ore. Other macrophages would open for other macrophages to come in and eat up the ore. This cycle could increase collagen and hyaline substances in lung as macrophage would eat up silica and digest it causing its decay. Macrophage is a prime mechanism in eating up and fighting with tuberculosis. Thus, when macrophage cells have decayed, silicosis patients could easily have infected by tuberculosis causing silicosis patient to also become tuberculosis patient [14-16].

2) Lung defense mechanism

All the time, breathing system would get in touch with air which is extermal environment by breathing in air from outside atmosphere all the time. The air having breathed in might contains various unknown matters which come in variety of forms such suspended particle, aerosols, or gas which, in general, are smaller than 5-10 micrometers. Consequently, they could be breathed in through lower respiratory tract and lung air bag. The particles with the size of about 10 micrometers would be left over in the nose and upper respiratory tract and could be got rid of by cough clearance mechanism. Particle with 5 micrometer size could be left over in lower respiratory tract. It can be removed by mucociliary clearance. Those with the size of 1-2 micrometers would be left over in the lung air bag and could be got rid of by the process of alveolar clearance. The particles less than 0.5 micrometers and other kinds of gass could be breathed in with minimal leftover in the lung air bag. Lung defense mechanism includes the physical ones to filter the contaminants to be left over at various levels of breath. Automatic mechanisms are coughing, sneezing, or trachea narrowing, for example. The crucial mechanism is mucociliary transport which utilizes cilia along the cells of epithelium respiratory skin along with mucus released to cover the skin cell. Particles left over in the lung air bag would be sucked in by phagocytosis process of alveolar macrophage. The process functions as the mechanism get rid of foreign matters without any exception [16,61,64].

3) Clinical description and sign & symptoms of silicosis

Silicosis could be classified along the lung pathology and over common factors such as duration of encountering with crystalline silica dust, patient's individual factors, and amount of crystalline silica dust having been taken, into 3 types, as follows [7,16]:

3.1) Chronic silicosis - This type of silicosis could occur with the ones encountering with crystalline silica dust for 10 years. The pathology of this kind of silicosis could eventually occure starting from nodul resulted from having got in exposure to crystalline silica dust for a long period of time. The patient had breathed in the crystalline silica dust which has less than of 30% of quartz. The silica crystals left over in lung would be eaten up by macrophage and removed to the lung air bag or lymph nodes at the lung terminal. When macrophage died away, such area would become the nodule composed of silica crystals in the lung tissues. Patients of this category would not show any syndrome in first phase of time. Later on, however, they would easily feel tired when getting physical exercise, the syndrome found among aging people. The patients would begin with coughing with some but not much phlegm. The syndrome is difficult to be sorted out from chronic bronchitis resulted from cigarette smoking. Later, the patient might get dyspnea or shortness of breath which would be more serious if the lung sizing down or atelectasis. The lung would be easily infected or fibrosis. In the case joint tuberculosis, it could be found that patients could cough out with blood, decreasing weight, or frequent dyspnea due to the membrane in lung to the point he or she could not eat enough food. Finally, the patients could encounter with respiratory failure particularly when they have leaks in lung (pneumothorax). In checking physical conditions, no abnormality is found. In chest radiograph, abnormality could be found when the person abnormality has last long. Some cases might take up 20 years to be found getting the problem. Consequently, there is a need for lab examination. Simple silicosis would not show any sign after getting in exposure with for 10-40 years. The person would not show any symptoms except when he or she has also got chronic obstructive pulmonary disease (COPD). Most of them would show up some syndrome when the disease has progresses generating membrane in lung (progressive massive fibrosis). He or she would be tired and has strong coughing with phlegm.

3.2) Accelerated or Subacute silicosis - This desease could grow with faster rate than the chronic one taking about 5-10 years. One could get it from breathing ni the dust that is with 40-80% of quartz. When getting more crystalline silica dust into body, the patients would have the syndrome that looks chronic but it has stronger impact than the first kind. The fibrotic nodules would be less than those of the chronic one and fibrosis would stick up the middle of of lung. The deterioration of pulmonary function would be faster than that of the chronic one.

3.3) Acute silicosis - Patients with this type would fastly get the syndrome for a few weeks to 5 years as they have got tremendous amout of crystalline silica dust within short time period. The patients with history of getting in touch directly with silica dust would be possible to get it. The disease pathology could be visualized in form of dots distributed on both sides. The pathology is similary to that of the chronic one except it comes up in the fast period of time and the silicotic nodule is tinier. The symptom of lung disease might come up vary fast. After touching it for 1-2 weeks, the patient would have trouble in breathing followed by having some dry cough for 1-2 months. Later on, the patient would be encountered with chest oppression and out of breath along with weight loss and could possibly die from heart failure.

4) Diagnosis criteria

The diagnostic criteria of occupational diseases commemorative edition on the auspicious occasion of His Majesty the King's 80th Birthday Anniversary in 2007 for Pneumoconioses - Silicosis included 3 criteria as follows [17]:

4.1) The patient has work history in risk group occupations interacting with the stone mineral dusts for at least 2 years.

4.2) From the chest radiograph on the chest, the patient has some abnormality from profusion of 1/1 and up along the criterial of ILO system of classification of radiographs of pneumoconiosis issued in 2011.

4.3) Having sign of pathology of lung biopsy or epidemic evidence to support

In conclusion, PM_{10} and crystalline silica dust could get through nose and neck to lung. Having been in exposure with it for a long period of time would have negative strong impact on the individual's health. From the researches done, it has been found that getting in exposure to PM_{10} and crystalline silica dust in the working areas and environment could adverstly affect the respiratory symptoms, pulmonary function, and leading to silicosis [18-21,23]. This is because all these PM_{10} and crystalline silica dusts would have reaction to the tissues in the lung decreasing the body immunity. Besies body and mononuclear phagocyte in lung have less effectiveness affecting health and wellbeing of the individual who directly gets in exposure to PM_{10}

and crystalline silica dust and those living in the community surrounding these sources of air pollution. It affects respiratory system leading to coughing and symptoms of lower respiratory system, heart system, brood vessel, eye system, skin system, and lung cancer, for example. Particularly, in PM_{10} containing crystalline silica dust could lead one's to silicosis. At the present, this disease has not specific curing approach to help the silicosis patients to gain better condition nor completely cured. Nonetheless, early detection is essential to detect and can help diagnosis and prognosis of the disease [52,65-69].

1.4.3 Effects of crystalline silica on respiratory disorders

Respiratory disorders are the major health effect of PM_{10} containing crystalline silica exposure in workers and people living around stone factories. PM_{10} containing crystalline silica can cause short-term adverse health effects or acute symptoms and long-term adverse health effects or chronic symptoms which could cause serious illness and premature death [70]. PM_{10} is one-sixth of human hair diameter which it is inhalable into the lungs and can induce adverse health effects. PM_{10} could get deeper into lower respiratory system. Particle or inhalable dust in working environment that has many sizes and could affect health is particle breathed in by human into their respiratory system. Health effects depends on size and components of the dust. When people get it, it could affect many systems of health such as respiratory system which causes coughing and symptom of lower respiratory system, heart system, and blood vessel such as heart attack, arrhythmia, and heart failure, eye system, and skin system [71-73]. PM_{10} also increases the risk of death from stroke and reduce the low birth weight. It could increase the rate illness and premature death from respiratory disorders in heart system and blood vessel along the concentration of the dust in the air. Silicosis and coal workers' pneumoconiosis could cause lung disease. Especially, the risk group such as asthma patient and COPD patient could avoid exposure to sandstone dusts or crystalline silica. Moreover, PM_{10} would access their body via breathing causing pneumonia, emphysema, and, tuberculosis possibly leading to illness and premature death [66-69,74].

Basing on literature and research review concerning the effects of crystalline silica on respiratory disorders, the researcher had decided to study silicosis with chest radiograph, pulmonary function, respiratory symptoms, inflammatory biomarkers as follow.

1.4.3.1 Effects of crystalline silica on chest radiograph

Using large film along the standard of ILO (International Classification of Radiographs of Pneumoconiosis, 2011), the researcher found chest radiograph that showed abnormality at the level of Profusion 1/1 and up, such as seeing small round nodular lesion or fibrosis difused all over the lung particularly the upper part or lower part of lung or limestone left over aroun hilar node [17,75].

From reviewing the literature and researches related to the measurement on silicosis as summarized below:

Aungkasuvapala et al. studied silicosis and pulmonary tuberculosis in stone-grinding factories in Saraburi, Thailand in 1995, which found the incidence of silicosis that were found to be 9% of workers [28].

Danphaiboon et al. studied blood HO-1 levels in stone mill workers in Upper North Thailand in 2012, which there were no lung lesions in of chest radiograph in stone mill workers [25].

Nambunmee et al. studied increased serum HO-1 in silicosis-suspected subjects in limestone crusher factories, Thailand in 2014, which there were 4 silicosis-suspected subjects and the increased serum HO-1 level was specifically related to silica exposure and chest radiograph finding independently from age and smoking status [30].

Nambunmee et al. studied serum HO-1 level in silicosis patients and stonemortar and pestle production workers, Thailand in 2014, which there were 19 subjects with silicosis [31].

Rafeemanesh et. studied respiratory diseases among agate grinding workers in Iran in 2014, which found the prevalence of silicosis among agate workers was 12.9% (95% CI: 7.9%-18.0%); 18 workers had simple and 4 had complicated silicosis. There was a significant ($p<0.05$) relationship between contracting silicosis and exposure duration [19].

Silanun studied the development of a disease surveillance system for silicosis among stone carving workers in Thailand, which found the prevalence of radiographic change was 8.9% (68 subjects). There were 66 subjects with parenchymal lesions and profusion (>grade 1/0 as per ILO classification). Two subjects have pleural abnormalities. Importantly, 55 cases among 68 with radiographic abnormalitieswere compatible with tuberculosis; 32 of whom showed no clinical evidence of tuberculosis in 2014 [32].

Bang et al. studied silicosis mortality trends and new exposures to respirable crystalline silica, United States in 2015, which found 1,437 decedents had silicosis as death or the underlying cause which were aged 15-44 years and the most of males 1,370 (95.3%) between 2001 and 2010 [26].

Tse et al. studied prediction models and risk assessment for silicosis using a retrospective cohort study among workers exposed to silica in China in 2015, which there were 203 (23.28%) incident silicosis cases from the high risk group (risk score≥5.91) and 4 (0.46%) cases from the low risk group (risk score<3.97) [27].

Silanun et al. studied orevalence of silicosis among stone carving workers at Sikhiu District Nakhonratchasima Province, Thailand 2017, which silicosis was reported to occur in 36.1% among stone carvers [33].

Basing on literature and research review concerning the chest radiograph, the researcher had decided to use chest radiograph with ILO standard. In addition, the researcher had checked the concerning disease to find out disease associated with crystalline silica exposure as following:

1) Silicosis

The study conducted by Nambunmeee et al. (2014) reveal that there were 4 silicosis-suspected subjects in chest radiography [30]. Torres et al. (2015) found that 35.9% prevalence of pneumoconiosis in the subjects (42.3% in region 1 and 29.9% in region 2) [76]. Rafeemanesh et al. (2014) found that the prevalence of silicosis was 12.9% (95% CI: 7.9%-18.0%); 18 workers had simple and 4 had complicated silicosis [19]. Silanun (2014) found that the prevalence of radiographic change was 8.9%(68 subjects). There were 66 subjects with parenchymal lesions and profusion (>grade 1/0 as per ILO classification). Importantly, 55 cases among 68 with radiographic abnormalitieswere compatible with tuberculosis; 32 of whom showed no clinical evidence of tuberculosis [32].

2) Lung cancer

The study conducted by Ross and Murray (2004) found that coal workers' pneumoconiosis, asbestos related diseases, lung cancer and other occupational respiratory diseases remain of considerable importance even after mining operations cease. While mining exposures contribute significantly to lung disease, smoking is a major factor in the development of lung cancer and chronic obstructive airways disease necessitating a comprehensive approach for prevention and control of mining-related occupational lung disease [77].

3) Tuberculosis

From the study carried out by Rees and Murray (2007) found that exposure to crystalline silica dust causes multiple diseases that silicosis and silica dust associated tuberculosis [78]. Milovanović et al. (2011) had stated that tuberculosis was the incurrent disease mostly found along silicosis. In the case silicosis patient with whom tuberculosis was found with silicosis is called silicotuberculosis [79].

4) Other diseases

The study conducted by Chaisabai et al. (2012) found that asthma 1.7%, bronchitis 1%, emphysema 1.7%, pneumonia 0.1% and allergy 1.4% [80].

1.4.3.2 Effects of crystalline silica on pulmonary function

PM_{10} and crystalline silica dust could get through nose and neck to lung. Having been in exposure with it for a long period of time would have negative strong impact on the individual's health. From the researches done, it has been found that exposure to PM_{10} and crystalline silica dust in the working areas and environment conditions could adverstly affect the respiratory symptoms, pulmonary function, and leading to silicosis [18-21,23]. Therefore, the pulmonary function test had the objectives to survey the performing ability of lung such as checking if the volume and capacity of pulmonary normally function or to what extent is fails to let the air to float through the lung, its ability in gas converting, for example [81]. The diagnostic criteria of occupational diseases commemorative edition on the auspicious occasion of His Majesty the King's 80th Birthday Anniversary had stated that, in initial period, from the chest radiography, there was nothing abnormal. When the decease expanded, there might be some evidence of restriction and deceasing diffusion. In certain cases, the irreversible airway obstruction was also found. The level of severity is relative to the level of abnormality. Though the individual might no longer get in exposure to PM_{10} and crystalline silica dust and, as technically known. The lung capacity had still continuously deteriorated, however [17].

From reviewing the literature and researches related to the measurement on pulmonary function as summarized below:

Meijer et al. studied respiratory effects on concrete dust containing crystalline silica in the Netherlands in 2001, which found the significant associations of exposure to concrete dust with a small pulmonary function (FEV_1/FVC ratio) loss [23].

Nordby et al. studied exposure to thoracic dust, airway symptoms and lung function in cement production workers in 2011, found that FEV_1 showed an exposure-response relationship with a 270-mL deficit of FEV_1 (95% CI 190-300 mL) in the highest compared with the lowest exposure level [67].

Danphaiboon et al. studied the situation of pulmonary function in the stone mill workers, Upper North Thailand in 2012, which found the correlation between serum HO-1 levels and percentage of FEV_1/FVC was negative significance (r= -0.219, p<0.01) [25].

Kakooei et al. studied respiratory health at a cement factory in the east of Iran in 2012, which showed significant reduction in FEV_1, FVC, and $FEF_{25-75\%}$ (p<0.05) in exposed workers compared to the unexposed group [24].

Patto et al. studied the abnormality of pulmonary function from crystalline silica dust exposure who worked in automotive part foundry, Thailand in 2014, which found pulmonary function test indicated that 24 percent of the workers had mild restrictive lungs (decreased FVC, FEV_1, $FEF_{25-75\%}$). Cough, phlegm and shortness of breath were significantly associated with reduced lung function (p=0.001, 0.034 and 0.024, respectively) [22].

Rafeemanesh et al studied respiratory diseases in agate grinding workers in Iran in 2014, which found most frequent disorder observed in spirometry was the restrictive pattern (n=43, 30%) [19].

Das studied pulmonary function values among the brick field workers of West Bengal, India in 2015, which there was significantly lower pulmoray function in workers when compared with control group (p<0.001) [21].

From reviewing the literature and researches related to the measurement on pulmonary function, the researcher had decided to use spirometer for pulmonary function test and checked the pulmonary function to find out about FVC, FEV_1, and FEV_1/FVC.

1.4.3.3 Effects of crystalline silica on respiratory symptoms

Silicosis is the disease resulted from the exposure of sandstone dust or crystalline silica. When silica eventually penetrates the body into respiratory system and lung for a long period of time, it would accumulate more and cause of death from chronic disease [14,15]. At the beginning, the simple silicosis would not cause any symptom nor be tackled but could be monitored in form of nodules appearing in chest radiographs. At this stage, chest radiographs would not show any abnormality but if the person has increasing got in crystalline silica exposure, it could be come a progressive massive fibrosis and would begin to feel it [16,82]. Another effect is the pulmonary function volume having been reduced leading to shortness of breath, coughing, pain in the chest, when minimally exerting, heart working hard leading the death possibility in 5-10 years, etc. All these, however, depend on heath of the workers, amount and proportion of pure sandstone. Acute symptoms are mostly found among the workers who work in the areas full of sandstone dusts or factory which is all closed up without any good ventilation. Working in such condition for only 8-18 months, one could get the symptom of shock, uncomfortableness, stress, darkening skin due to the lack of oxygen, short breathing, fast breathing, etc. during which tuberculosis might come up [7,16].

From the study conducted by Patto et al. (2014), it was found that 25% of the workers had got many symptoms related to respiratory system such as coughing, having phlegm, wheezing, and shortness of breath while 35% had one syndrome - coughing, having phlegm, and shortness of breath which were significantly related to decreased pulmonary function (p=0.001, 0.034 and 0.024, respectively) [22]. Das (2015) had found that the syndrome of respiratory system among the brickworks comparing to control group was less with $p<0.001$ and the prevalence of respiratory system syndrome including the dyspnea was 46.8%, having phlegm was 39.2%, and oppression in the chest was 27.6%. Exposure to the dust in the working environment had affected the lung capacity and respiratory system of the brick workers [21]. Besides, Nkosi et al. (2015) [20] also found that the elders who had been exposed to the dust would had higher prevalence, with statistical significance, of chronic respiratory system and other chronic diseases than those unexposed ones [20]. This shows that residing near mine dumps has significant relationship with asthma (Odd Ratio (OR)=1.57; 95% CI: 1.20-2.05), chronic bronchitis (OR=1.74; 95% CI: 1.25-2.39), chronic cough (OR = 2.02; 95% CI: 1.58-2.57), emphysema (OR = 1.75; 95% CI: 1.11-2.77), pneumonia (OR = 1.38; 95% CI: 1.07-1.77) and wheeze (OR = 2.01; 95% CI: 1.73-2.54). Those who lived in the community were current smokers, previous smoker, and had low level of education were at risk to getting chronic respiratory system and other chronic diseases. This has shown that chronic syndrome of respiratory system and other chronic diseases were frequently found among elders residing in the community near the mine.

From reviewing the literature and researches related to the measurement on respiratory symptoms as summarized below:

Moondee et al. studied the situation of respiratory symptoms in Saraburi Province, Thailand in 2006, which found that the prevalence of all respiratory symptoms of students in Bankoktoom school was statistically significant lower than students in Naphralan school [57].

Yadav et al. studied the sandstone quarry workers in desert ecology of jodhpur, rajasthan, India in 2011, which found that about one-third (32.7%) of the sandstone quarry workers attributed cough with breathing difficulties as the most important symptom of silicosis but some of the respondents also mentioned fever with loss of weight (20.7%) or weakness, fever for more than 15 days (20.5%), loss of appetite and fever in the evening (12.2%) as main symptoms of silicosis [18].

Patto et al. studied the abnormality of pulmonary function from crystalline silica dust exposure who worked in automotive part foundry, Thailand in 2014, which found 25 percent of the workers reported multiple respiratory symptoms including cough, phlegm, wheezing and shortness of breath whereas 35% had single symptom including coughing, phlegm and shortness of breath among automotive part foundry workers [22].

Rafeemanesh et al. studied respiratory diseases in agate grinding workers in Iran in 2014, which found that 20 workers (11.7%) had symptoms consistent with chronic bronchitis and 8 workers (4.7%) showed asthma and asthma-like symptoms in agate grinding workers in Iran [19].

Das studied respiratory symptoms among brick field workers of West Bengal, India in 2015, which the prevalence of respiratory symptoms, dyspnea was 46.8%, phlegm was 39.2%, and chest tightness was 27.6% [21].

Nkosi et al. studied chronic respiratory disease among the elderly in South Africa in 2015, which found the prevalence of chronic cough was 26.6%, wheeze was 24.7%, asthma was 17.3%, pneumonia was 17.1%, chronic bronchitis was 13.4%, emphysema was 5.6%, and in the exposed communities was higher than that of the unexposed communities around mine dumps in Gauteng and North West Province, in South Africa [20].

From the literature review on abnormalities of the respiratory symptoms from PM_{10} and crystalline silica exposure, the researcher had used the questionnaire to survey about the respiratory symptoms with American Thoracic Society Division of Lung Diseases (ATS-DLD 78A).

1.4.4 Biomarkers of crystalline silica exposure

At present, diagnosis of silicosis includes medical history, and radiographic results, which has no effective treatment with one-time diagnosis. Diagnosis and prenatal diagnosis for these diseases are advantageous for treatment. As a result, testing with biological indicators is essential as it can help in diagnosis and identification before the disease occurs [34,35].

Pathologic mechanisms of silicosis are caused by the inhalation of crystalline silica. Exposure to PM_{10} containing crystalline silica can enter a nose, throat, and lungs if exposed for a long period of time. After inhalation, silica particles are quickly engulfed by alveolar macrophages and in response these cells release inflammatory mediators. The pathologic mechanisms of silicosis were caused by sandstone dust which accumulated into lung biopsy. Body reaction to sandstone dust led to inflammation. Body builds up white blood cell to eat up the sandstone dust, generating cytokine, secretions, and free radical particularly alveolar, macrophage, and monocyte. However, at the sandstone dust is an inorganic compound, it is hart to destroy. When white blood cells eat upthe small sandstone dust, it would create tremendous amount of free radicals in the cells causing their necrosis before release the sandstone dusts getting out of white blood cell to lung biopsy waiting for other white blood cells to eat up. The cell dies and free radicals increase leading the cycle for the cells and lung biopsy to create lipid peroxidation. Deoxyribonucleic acid (DNA) damages organelle which, for a long period of time, would create abnormal collagen and the emergence of membrane (fibrosis) to the point that lung could not function normally [83]. It is evident that CC-16 and HO-1 has antioxidative, antiapoptotic and anti-inflammatory activities in the lung lining fluid. All these biomarkers are sensitive enough to detect crystalline silica dust in respiratory tract [34].

CC16 is a 16-kDa homodimeric protein secreted in airways by non-silicated clara cells of the tracheobronchial tree [39]. CC16 increasingly reflect the very early toxic effects of silica particles to protect the respiratory tract against oxidative stress and inflammation in the human respiratory epithelium [34,39]. Consequently, in this study, the biological indicators for abnormality of respiratory system would utilize the CC-16 in serum as biomarker. Clara cell is a type of respiratory mucosa cell that could produce CC-16 protein in the respiratory system during the time respiratory system and lung have been inflamed opening for CC-16 running into blood stream. Thus CC-16 could serve as the biomarker at the beginning period of abnormality in respiratory system. Normally, CC-16 in healthy people would take about 21.7 to 27.9 ug/L [84].

The HO-1 is a stress response protein and acts as an antioxidant enzyme. Many researchers suggested that this protein helped prevent ROS inducing airway inflammation from crystalline silica exposure, which has a key role in the development of silicosis [34,40]. The reduction of antioxidant enzymes such as superoxide dismutase (SOD), HO-1, catalase, glutathione reductase and peroxidase was involved in the toxicity mechanism of silica as described elsewhere [85,86].

These mechanism of serum CC16 and HO-1 can identify suitable biomarkers of exposure, effect, and susceptibility for silicosis. In the present, Silicosis diagnosis is based on clinical history and radiological findings that do not have effective treatment and once diagnosed [35]. Early diagnosis and prognosis for these diseases is advantage to their treatment. Therefore, biomarker detection is the potential things due to it can indicate early prognosis of these diseases [34].

From reviewing the literature and researches related to the measurement on serum CC16 and HO-1 biomarkers of crystalline silica as summarized below:

Bernard et al. studied early decrease of serum clara cell protein in silica-exposed workers in 1994, which serum CC16 concentration was decreased in exposed workers (geometric mean 12.3 micrograms) with in controls (16.3 micrograms) [38].

Sato et al. found that serum HO-1 levels were significantly increased in subjects with silicosis compared with age-matched control subjects or patients with COPD in 2006 [40].

Wang et al. studied serum CC16 in the early diagnosis and progression of silicosis in 2007, which serum CC16 concentrations decreased in exposed workers compared to controls using enzyme-linked immunosorbent assay [87].

Ruchirawat et al. studied health effects of exposure to carcinogenic volatile organic compounds in Rayong Province, Thailand in 2010, found that CC16 levels in serum in serum could serve as the indicator of inflammation of respiratory at beginning period and low CC16 levels in serum. The low CC16 levels could serve as the indicator of exposing to pollution affecting respiratory system for a long period of time [84].

Snyder et al. found clara cells in 2010 can attenuate the inflammatory response through regulation of macrophage behavior, and suggest that epithelial remodeling leading to reduced clara cell secretory function is an important factor that increases the intensity of lung inflammation in chronic lung disease [88].

Nambunmee et al. studied biological markers application in silicosis risk screening in 2015, found that HO-1 was proposed as a potential biomarker for silicosis in order to HO-1 related to oxidative stress in lung tissue caused by silica dust exposure. He said that quantity of CC-16 serum among the individuals who had been exposed to sand stone dust was 12.3 micrograms per liter compared with 16.3 micrograms per liter of control group differencing at statistical significance level. The decrease of CC-16 in the workers having been exposed to sand stone dust is the signal indicating the change at the beginning level of lung issue after expose in sand stone dust. Moreover, there is also a relationship between lung inflammation and chronic pneumonia and level of CC-16 in patients [83].

Basing on literature and research review concerning biomarkers of crystalline silica, the researcher had decided to use CC16 and HO-1 as the mean of analyzing the substance.

1.4.5 Risk perception and preventive behavior of inhalable dust exposure

1.4.5.1 Risk perception of inhalable dust exposure

The perceived level of air pollution in occupational or living environments affects to change in self-protective behavior to avoid health risks. Empirically, it has been found that air quality perception (AQP) varies positively with health risks perception and low level of AQP results in low level of self protective pursuits. In other words, people having high level of awareness about health risks from air pollution tend to have stronger self-protective behaviors than those having low level of awareness. As a result, it is imperative to find out whether or not people living in the neighborhood of stone-mortar factories have risk perception as well as health risks awareness. The lack of awareness or the low level of perception means the low likelihood for the individual to behave in self protective ways to avoid the harm from air pollution [43-47,89].

Furthermore, it has been found that AQP varies positively with health risks perception and that low levels of AQP result in low levels of self protective pursuits. In other words, people having a higher level of awareness regarding health risks from air pollution tend to have stronger self-protective behaviors. The present research found that perceptions of the overall environmental changes and negative physical changes in 2011 were 39.3% and 43.0% respectively among people who living around the mining industry, Chonburi Province. Moreover, the environmental changes due to the mining industry had an influence on healthproblems including allergies, respiratory health problems, and silicosis [90]. The average score of perceived air pollution level was 46.9 (95% CI = 46.0 to 47.8) in Viwandani and 41.4 (95% CI = 40.9 to 41.9) in Korogocho. The average score for perceived level of health risk related to air pollution was 43.6 (95% CI = 42.7 to 44.5) in Viwandani and 44.6 (95% CI = 44.1 to 45.1) in Korogocho, Nairobi Slums, Kenya, 2013 [44]. Women in the agricultural community had significantly increased physical health, mental health and 36-item short form (SF-36) scores compared with those in the mining community among indian women in mining and agricultural communities in 2013 [65]. Therefore, the ILO/World Health Organization (WHO) joint committee on occupational health launched in 1995 a global programme on the elimination of silicosis from the world by 2030 [13].

As perception can be influenced by the distance from pollution sources, this spatial dimension becomes a focal point in this study. Although by nature and from various reports ambient air pollutants concentration will be high at and around the point source of pollution, the air pollutants can be dispersed to more remote communities at high concentrations and thus can pose health risks to the residents there [69,91]. To tackle this issue, many researches have applied geographic information system (GIS) technique for mapping the spatial dispersion and concentrations of air pollutants generated from a point source, or for studying the relationship between distance and air quality or health risks perception of residents in the affected area. However, from literature review, meager studies and researches have been undertaken related to the implications of stone mortar production as it is generally an informal cottage industry in various developing countries where appropriate occupational and environmental health protective measures are still lacking [92-94].

From reviewing the literature and researches related to the measurement on risk perception of exposure to PM_{10} and crystalline silica dusts as summarized below:

Deguen et al. studied association between pollution and public perception of air quality-SEQAP, a risk perception study in France in 2008, found that AQP score increased with the particles level. However, the association between PM_{10} and AQP score remained significant after exclusion of these susceptible groups. AQP was significantly association with ozone (p=0.001), but only in the summer season [95].

Badland et al. (2009) studied perceptions of air pollution during the work-related commute by adults in Queensland, Australia in 2009, found that 45% of the subject perceived air pollution negatively affected health outcomes when commuting to/from work, and 3% recognised air pollution as a major barrier to walking or cycling to/from work [96].

Pokawinpudisnun et al. studied dust hazard risk perception and protection behaviors among ceramic factory workers in 2009, found that 84.2% of the subjects had overall dust hazard risk perception at a high level. The aspect of dust hazard risk perception including knowledge of health hazard from dust exposure, awareness of dust exposure prevention, and cause of dust were also reported at a high level (67-85%) [97].

Kumpiranont et al. found that perceptions of environmental and negative physical changes in 2011 were 39.3% and 43.0% respectively. Impact upon health and the negative impact upon health were found to be 35.2% and 39.5% respectively. People who lived less than or equal to 1 kilometer from the mining area had significantly different perceptions ($p<0.05$) when compred to those who more than 1 kilometer from the mining area about environmental changes and their negative impact upon health [90].

Shi and He studied the environmental pollution perception of residents in coal mining areas: a case study in the Hancheng mine area, Shaanxi Province, China in 2012, found that the majority of the residents in the coal mine area are not satisfied with their living environment. The perception order of pollution severity is: air pollution > noise pollution > sanitation > water pollution. The residents think that pollution is mainly caused by coal processing [47].

Egondi et al. studied community perceptions of air pollution and related health risks in Nairobi Slums in 2013, found that the average perceived air pollution level was higher among residents in Viwandani compared to those in Korogocho. Perceived air pollution level was positively associated with perceived health risks [44].

Charles et al. studied a cross-sectional survey on knowledge and perceptions of health risks associated with arsenic and mercury contamination from artisanal gold mining in Tanzania in 2013, found that knowledge and risk perceptions concerning mercury and arsenic exposure, with 40.6% (n=65) and 89.4% (n=143) not aware of the health effects of mercury and arsenic exposure respectively [48].

Omanga et al. studied industrial air pollution in rural Kenya: community awareness, risk perception and associations between risk variables in 2014, found that a significant association between industrial pollution as a risk and, perception of risk from other familiar health hazards. The most important factors influencing the respondents' pollution risk perception were environmental awareness and family health status [49].

Basing on related literature review on perception on the health risk from exposure to PM_{10} and crystalline silica dusts, the researcher had used the questionnaire on perception on health risk. Moreover, our literature reviews found that factors associated with risk perception by crystalline silica exposure as follow:

1) Sex

From the study conducted by Kumpiranont et al. it was found that most of the workers in 2011 were females (75.6%), followed by males (24.4%) [90]. Chanprasit et al. had found that most of the workers in 2011 was females (80.34%) [97] and Shi and He found that most of them in 2012 were males (56.8%) followed by females (43.2%) [47].

2) Age

From the study conducted by Kumpiranont et al., it was found that most of them in 2011 were between 49-77 years old (57.0%) followed by 7-48 years old (43.0%) [90]. Chanprasit et al. found that most of them in 2011 were 18-60 years old and average age of 35.74 years [97]. Shi and He found that most of them in 2012 were 30 years old and older (36.3 %) followed by 30-40 years old (27.5%) and 41–50 years old (18.7%) [47].

3) Education

From the study conducted by Kumpiranont et al., it was found that most of them in 2011 had completed secondary education (51.3%) followed by certificate of vocation education (33.5%) [90]. Chanprasit et al. (2011) found that most of them in 2011 were with primary education [97]. Shi and He found that most of them in 2012 were with secondary education (39.9%) followed by primary education (32.8%) [47].

4) Marital status

From the study conducted by Chanprasit et al. found that most of them in 2011 had married [97].

5) Occupation

From the study conducted by Kumpiranont et al., it was found that most of them in 2011 were employees (47.9%) followed by house keeper (28.1%) [90]. Xingmin Shi and Fei He (2012), it was found that most of them in 2012 were freelance (25.1%) followed by industry and mining employees (22.0%) [97].

6) Length of living in the community

From the study conducted by Kumpiranont et al., it was found that most of them in 2011 resided in the area for 1-40 years (53.0%) followed by resided in area for 47-77 years (47.0 %) [90].

7) Income

From the study conducted by Geer et al., it was found that most of them in 2006 had 35,000-49,000 USD yearly income (41.6%) followed by 50,000-74,000 USD yearly income (27%), 74,000 USD (15.7%), and less than 35,000 USD yearly income (15.7%) [98]. Chanprasit et al. had studied and found that most of them in 2011 had 3,000-9,000 Baht per year [97].

1.4.5.2 Preventive behavior of inhalable dust exposure

Health behavior, according to WHO, is referred to any behavior carried out by individual or his/her health perception aiming at promoting health care and preventing the problems in effective way [99].

From reviewing the literature and researches related to the measurement on preventive behavior of exposure to PM_{10} and crystalline silica dusts as summarized below.

Pokawinpudisnun et al. studied dust hazard risk perception and protection behaviors among ceramic factory workers in 2009, found that with regard to protection behaviors, 82.8% of the subjects had overall protection behaviors at a moderate level. Regarding each aspect of protection behaviors, 74.3% of the subjects had work practice at a moderate level while 58.3% of the sample used personal protective equipment at a high level. In addition, it was found that overall dust hazard risk perception showed positive significant relationship with overall protection behavior at a low level ($p<0.01$). Each aspect of dust hazard risk perception was also found to be positive significant relationship with overall protection behavior at a low level ($p<0.05$ and $p<0.01$) [97].

Ahmed et al. studied dust exposure and respiratory symptoms among cement factory workers in the United Arab Emirates in 2012, found that the few workers (19.5%) who used masks all the time had a lower prevalence rate of respiratory symptoms than those not using them. High dust level was the only variable that influenced the workers to use the mask all the time [100].

Siripanich et al. studied incense and joss stick making in small household factories, Thailand in 2014, found that only 3.9% of female workers used personal protection equipment [101].

Basing on related literature review on self-protecting behavior from exposure to PM_{10} and crystalline silica dusts, the researcher had used the questionnaire on self-protecting behavior. Moreover, our literature reviews found that factors associated with preventive behavior by crystalline silica exposure as follow:

1) Sex

From the study conducted by Chanprasit et al., it was found that most of them in 2011 were females (80.34%) [97]. Siripanich et al., it was found that most exposed group in 2013 were males (88.8%) followed by females (11.2%) [101].

2) Age

From the study conducted by Chanprasit et al., it was found that most of them in 2011 were 18-60 years old (35.74%) [97]. Siripanich et al., found that most exposed group in 2013 were 15-34 years old (21.9%) followed by 35-54 years old (62.5%) and those who were more than 55 years (15.6%) [101].

3) Education

From the study conducted by Chanprasit et al., it was found that most of exposed group in 2011 had primary education [97]. Siripanich et al. found that most of them in 2013 had primary education (74.5%), followed by with secondary education level (19.4%), undergraduate education or higher (4.1%), no education (2.0%) [101].

4) Marital status

From the study conducted by Chanprasit et al., it was found that most of them in 2011 had been married [97]. Siripanich et al. found that most of them in 2013 had been married (83.7%), single (14.3%), divorced or separated (2.0%) [101].

5) Income

From the study conducted by Chanprasit et al., it was found that most of them in 2011 had yearly income of 3,000-9,000 baht [97].

6) Working steps

From the study conducted by Chanprasit et al., it was found that most of them in 2011 were at the step of coating and decorating (44.66%) and at the step of modeling (38.83%) [97].

7) Working duration

From the study conducted by Chanprasit et al., it was found that most working duration in 2011 was 1-5 years (39.56%) followed by 6-10 years (33.98%), and 6 months-20 years (26.46%) [97]. Siripanich et al. found that most of dust exposure in 2013 had more than 10 years of working duration (71.9%) followed by those with less than 10 years (28.1%) [101].

8) Working hours per week

From the study conducted by Chanprasit et al., it was found that most of them in 2011 had 48 working hours or less per week (87.14%) [97].

9) Smoking

From the study conducted by Siripanich et al., it was found that most of the dust exposure in 2013 did not smoke (61.2%) followed by still smoking at the present (38.3%) [101].

10) Alcohol drinking

Siripanich et al. found that most of the dust exposure in 2013 had drunken alcohol (55.1%) followed by non-alcohol drinking (44.9%) [101].

11) Personal protective equipments

From the study conducted by Chanprasit et al., it was found that most workers in 2011 used dust preventing tools (94.42%). The tools included nose mask which was occasionally used (60.67%), mask all the time (39.33%). Some prevented themselves from the dust by not working in the place which was full of dust (69.90%) [97]. Siripanich et al. found that most workers in 2013 appropriately dress such as wearing long-handed shirt and long-legged pants (74.5%), wearing cotton gloves (5.9%), cotton mask (3.9%), washing hands before eating or drinking (80.4%), taking a shower before taking lunch or dinner (39.3%) [101].

1.4.6 Health related quality of life concept

The concentration of PM_{10} could cause danger or inconvenience affecting physical health and mental health of workers and residents living surrounding source of the air pollution [71,102]. As risk factors on stress, emotion, thought, and behavior are crucial indicators of HRQOL, they could serve as the predictors of quality of life of the people residing nearby air pollution sources both of physical health and mental health as well [65,103].

Moreover, it has been found that the people residing nearby the air pollution source both in urban or rural areas would get its impact on physical health and mental health and quality of life in general [52,103]. They have problems on their mental health and physical health than those living far away from them basing on SF-36 scale [65,103]. For those who live in the rural areas, it was found that their level of education and knowledge was not sufficient for effectively and efficiently controlling the air pollution [4]. There are many researches applying GIS to study on the environment that affects the resident's health and epidemiology. GIS could be used to accurately measure the areas and distance from residing area to the sources of air pollution affecting health and quality of life of the people residing nearby the air pollution sources as well [104-107].

Health is an important factor of good quality of life. Consequently, the measurement of HRQOL is necessary. Besides, health life quality is also an important health outcome. The quality of life assessing tools having generally been used come two types: the one measuring a single aspect or the one measuring many aspects. The one to measure many aspects would focus on SF-36 and World Health Organization Quality of Life- BREF version (WHOQOL-BREF) has been widely used in Thailand. SF-36 is a tool for assessing life quality in general widely used all over the world. It has validity and reliability and has been translated into many languages all over the world including Thai. SF-36 is the questionnaire constructed by Ware, et al., in United States of America. It has 36 items classified into 8 dimensions, namely, physical functioning (PF), role limitation due to physical problems (RP), role limitation due to emotional problems (RE), bodily pain (BP), mental health (MH), vitality (VT), social functioning (SF), and general health (GH) perceptions [108-110].

From reviewing the literature and researches related to the measurement on quality of life to PM_{10} and crystalline silica exposure as summarized below:

Ware and Gandek, studied overview of the SF-36 health survey and the international quality of life assessment (IQOLA) project in 1998, found that SF36 health survey evaluated validity and reliability and provides administrative and interpretation guidelines for the SF-36 [108].

Jenkinson et al. studied assessment of the SF-36 version 2 in the United Kingdom in 1999, found that internal consistency of the different dimensions of the questionnaire were found to be high [111].

Yamazaki et al. studied association between ambient air pollution and health-related quality of life in Japan in 2005, found that SF-36 is important for, and needed by, public health policy makers, because assessing the health effects of air pollution by measuring the HRQOL would provide a new method for formulating air pollution policies [112].

Zullig et al. studied a comparative analysis of HRQOL for residents of U.S. counties with and without coal mining in 2010, found that residents of coal-mining counties inside and outside of Appalachia reported significantly fewer healthy days for both physical and mental health, and poorer self-rated health ($p<0.0005$) when compared with referent U.S. non-coal mining counties, but disparities were greatest for people residing in Appalachian coal mining areas [52].

Liu et al. studied determination of ameliorable health impairment influencing health-related quality of life among patients with silicosis in China in 2011, found that median 36-item short-form health survey physical component (PCS) and mental component (MCS) scores were 47.17 and 51.05, respectively. Lower than median PCS scores (<47) were significantly associated with high levels of symptom and activity impairment. Lower than median MCS scores (<51) were significantly associated with high levels of depression and activity impairment [113].

Zullig et al. studied HRQOL among central appalachian residents in mountaintop mining counties, found that residents of mountaintop mining counties reported significantly more days of poor physical, mental, and activity limitation and poorer self-rated health ($p < 0.01$) compared with the other county groupings [114].

D'Souza et al. studied factors associated with HRQOL among Indian women in mining and agriculture in 2013, found that women in the agricultural community had significantly increased physical health, mental health and SF36 scores compared with those in the mining community. Years of stay, education and employment were significant predictors among women in the agricultural community. 39% (33%) and 40% (26%) of the variance in physical and mental health respectively among women in agricultural and mining communities are predicted by the structural, health and psychosocial variables [65].

Having reviewed the literatures and researches relating to HRQOL, the researcher had decided to use the questionnaire of SF-36. Moreover, our literature reviews found that factors associated with quality of life by crystalline silica exposure as follow:

1) Sex

From the study conducted by Yamazaki et al., it was found that the dust exposure in 2005 were equally males and females (50% each) [112]. Liu et al. (2011) found that they were males (75.5%) and females (24.5%) in 2011 [113]. Han et al. found that they were males (77.47%) and females (22.53%) in 2013 [115].

2) Age

From the study conducted by Yamazaki et al., it was found that most workers in 2005 were 40-49 years old (21%), followed by 50-59 years old (20%), and less than 30 years old (19%) [112]. D'Souza et al. found that most of them in 2013 were 30-39 years old followed by less than 30 years old [65]. Han et al., it was found that most workers in 2013 were more than 60 years old (87.96%), followed by less than 60 years old (12.04%) [115].

3) Marital status

From the study conducted by D'Souza et al, it was found that most workers in 2013 were married followed by separated/divorced [65]. Han et al. found that most of them in 2013 were married (77.16%) followed by divorced (22.84%) [115].

4) Education

From the study conducted by D'Souza et al., it was found that most of the workers in 2013 had secondary education followed by without any education and primary education [65]. Han et al. was found that most of the workers in 2013 had lower secondary education (61.11%) followed by primary education (28.09%) and lower secondary education (10.80%) [115].

5) Length of living in the community

From the study conducted by D'Souza et al., it was found that the workers in 2013 who lived in the mine community had resided for more than 20 years (40.7%) followed by residing for less than 10 years (36.6%) 36.6 and those who lived in the agricultural community, most had resided for 10 years (36.1%) followed by residing for less than 10 years (33.8%) [65].

6) Duration of dust exposure

From the study conducted by Han et al., it was found that most workers in 2013 had the dust exposure for 15-30 years (53.09%) followed by had the dust exposure it for less than 30 years (37.04%) and the dust exposure for more than 5 years (9.88%) [115].

7) Respiratory symptoms

From the study conducted by Yamazaki et al, it was found that most of the workers in 2005 had not disease (87%) followed by had it (2%) and missing data (11%) [112].

8) Smoker

From the study conducted by Han et al., it was found that most of the workers in 2013 were non-smokers (49.39%) followed by never smoke (38.27%) and presently smoking (12.36%) [115].

9) Alcohol user

From the study conducted by Han et al., it was found that most workers in 2013 had not drunk alcohol (75.62%) followed by used to drink (21.91%) and presently drink (2.47%) [115].

1.4.7 Dose-response relationships

1.4.7.1 Health risk assessment

There are 4 steps of assessing health risk due to PM_{10} and crystalline silica dust, namely: assessing the hazard, assessing the exposure, assessing the dose and response, and describing the risk characteristic. The whole process was to assess the health risk of people who had been exposed to the concentration of PM_{10} and crystalline silica dust (hazard) at a certain period of time [116].

1.4.7.2 Hazard identification

Objectives of identifying the hazards were to respond to the question if the threat has existed or not basing on 2 types of data - 1) data on injury or diseases related to the threat, and 2) conditions in which the threating substance is taking into body resulting the injury or diseases at last. Identifying the threating substance really affect the individual’s heath or not requires a lot of data which could be obtained from the study on laboratory animals, study on epidemiology with the population having been threated, clinical study, or reports on patients having been threated, for example. Data are important for assessing the risk assessment obtained from the study with laboratory animals and epidemiological data [116].

Hazard, in here, are referred to the pollutants widely affecting heath of the people causing the big and severe problems as follows:

1) The area having encountered with environmental problems from tiny dusts and having been announced as the area for pollutant controls since 2004.

2) The people residing near by the hazard source breathing is the dusts of size of PM_{10}, $PM_{2.5}$ and crystalline silica into body everyday resulting the threat to heath

Consequently, the threats used to assess the risk is PM_{10}, and crystalline silica [116].

In this research, the researcher would not study on the topic of assessing the hazard. The study concerning toxicity of crystalline silica affecting human heath was conducted in 1997 by IARC which took crystalline silica breathed in form of quartz or cristobalite being carcinogenic to humans classified in Group I [117].

The process of stone-mortar making includes the following steps:

1) Searching for raw materials for making stone-mortar. There are 2 kinds of stone to be used, namely, 1.1) granite which was taken from Mae Ka Subdistrict, Mueang District, Phayao Province, and Phan District, Chiang Rai province; and 1.2) sandstone taken from Pa Wai Subdistrict, Muang District, Phayao Province.

2) Penetrating and cleaving into stone-mortar form, and, 2.1) digging out the soil having rapped around out to cut the stone in pieces, and, 2.2) moulding the stone into the needed form.

3) The process to cut the stone into the needed form - 3.1) Putting the cut stone onto the stone cutter, 3.2) Passing through the cutting process, and, 3.3) the stone-mortar resulted from the cutting process.

4) The process to grinding into stone-mortar form 4.1) smoothing the outside and bottom of the stone-mortar to be further smoothed out by the grinding machine, 4.2) putting the stone through the grinding process by setting up the grinding machine into the right position to grinder the bottom of the stone-mortar, and 4.3) grinding down the stone into pit of the needed sized down, 4.4) smoothing inside of the stone-mortar's pit using knife to smooth up the pit.

5) Getting stone-mortar as designed.

1.4.7.4 Level of exposure basing on job type or job exposure matrix (JEM)

The process of stone-mortar making follows the procedural steps of 1) Finding the raw materials for making stone mortar, 2) Penetrating or cleaving to form the stone-mortar, 3) Process of cutting, and 4) Process of grinding in form of stone-mortar. Each step of work could generate different amount of PM_{10} and crystalline silica dust per worker. They then breath in different amount of PM_{10} and crystalline silica dust. There is a need for assessing the situation via the process technically known as JEM among SMW.

JEM is a phenomenon of the research in epidemiology and medical surveillance conducted by Coughlin and Chiazze in 1990 who had concluded that JEM was the method to assess the exposure which were adjusted along the research process. One advantage of exposure matrix was an avoidance of bias and statistical power. Nonetheless, some bias might still exist due to the misclassification of exposures.

Sensitivity of the method had not been proved for having been continuously carried in the extent higher than other normal approach of assessing the exposure. Nonetheless, it also dependes on the interview carried out by the volunteers [118].

JEM could be used to indicate the significant exposure to the dust in the working area. Sieber et al. (1992) had concluded that JEM was to link to the type of job to explain the situation. JEM was developed by NIOSH and JEM was a mechanism useful for studying the occupational diseases [119].

JEM as mentioned by Goldberg et al. (1992) was the JEM designed to link the data on working with the data of exposing to danger of the specific working area. Though there were some constraints, JEM is useful for studying epidemiology along large retrospective epidemiological model covering the design related to the JEM structure which was based on 4 points possibly make difference in the exposure - agent (exposure), job, time, and place [120].

JEM was the system of data on exposure for various purposes. In describing the JEM, Kauppinen (1998) had concluded that documents on Finnish job-exposure matrix (FINJEM) could be used for organizing the system of data on exposure in general for preventing the danger, estimating the risk, and monitoring the danger. FINJEM also covered physical, chemical, biological, ergonomical, and social psychological [121].

JEM as mentioned in Beyond the JEM: The Task Exposure Matrix (TEM) of Benke et al. (2000) was the matrix for assessing the accumulative exposure of a lot of workers checked on epidemiology. In obtaining quantitative data on the all the workers who had worked under the same job name and about the same exposure time, the data came up in form of $mg.m^{-3} \times$ years and method to decrease the variance of JEM which could also be regarded as TEM as well [122].

1.4.7.5 Exposure assessment

Exposure assessment is the method to estimate or measure volume or concentration of the threat each individual, group of population or ecological system got. Objectives of exposure assessment were to 1) search for substance or thing threating each type of organism or environment had got, 2) calculate the volume having been exposure to, 3) method of exposure, 4) for how long, and, 5) under which condition. We could classify the method of investigation into 2 types - exposure monitoring and exposure modeling [116].

Exposure monitoring is the most reliable method to obtain data on exposure and could provide good input data for assessing by the exposure model. Monitoring could assure the best collection of the data on exposure of population or environment we have been mostly interested with. There are two types of monitoring - personal monitoring and ambient monitoring [116].

Exposure model is a mathematic equation model used for predicting the value from various known and measurable factors. We could classify the model into 2 types - Release assessment model and Population exposure model [116].

The release assessment model was used to predict the concentration of the threat at a certain distance from its origin [116].

Population exposure model was used for assessing the risk population on health due to their exposure to such threat. The main goal was to answer the question how much the risk population would take would take the threats [116].

It could be assessed from the concentration of the pollutants, frequency of exposing to the, duration of exposure, and channel of exposure. The exposure would only be assessed in term of milligram per kilogram per day [116].

We assessed quantitative estimates of PM_{10} and silica exposure by using historical data on dust concentrations and working histories that those were calculated according to the following equation [123,124]:

$$\text{ADD}(PM_{10}, \text{Silica}) = (C \times IR \times ET \times EF \times ED) / (BW \times AT)$$

where ADD represents average daily dose (mg/kg/day), C=contaminant concentration in air (mg/m^3), IR=inhalation rate (0.83 m^3/hrs), ET=the exposure time (hrs/day), EF=exposure frequency (days/year), ED=exposure duration (years), BW=body weight (kilogram), and AT=the average time (days).

Then variables were valued in the formula for risk assessment along the unit set for each variable. At the end, the risk assessment could answer the question for how much the target group subjects had been exposed to the pollutants. The unit used was in term of milligram per kilogram per day (mg/kg/day). When exposure had been assessed, it could be used to carry out the dose-response assessment to be used further to calculate the risk probability further on [123,124].

1.4.7.6 Dose-response concept

When humans or laboratory animals had got the certain amount of dose of such threat, they would begin to show the sign of toxicity with frequency or severity of toxicity when exposure increased. The assessment of the dose and response was to respond to the question of what relationship between the size of dose and the response was. It could lead further to predict the response later on. Besides, such relationship could be used to identify the standard value for threat to find the level not harming health of the people. The factors for assessing the dose and response included toxicity and non-toxicity, dose determination, and response measurement, for example [116].

Toxicity and non-toxicity are the conditions of encountering with the threat with or without the impact on heath. Nonetheless, in the world, there is no substance without any poison. Consequently, zero risk is impossible in the real world. It is only that such risk is so minimal that it has no effect on the sample subject. The term “safe level” of a chemical either in food, drink, air, or working place, has been used to assure the individual touching the substance at such level would not have any negative impact on his/her heath [116].

Dose determination could be done in 2 ways along their size. The first one is absorbed dose which is the size that could be breathed in and absorbed through lung wall (via breathing), alimentary canal (via eating), and skin (via skin contacting). The internal or effective dose has the size that could turn into toxin or damage [116].

Response measurement could come up with 3 groups, namely, dichotomous response, continuous response, and, dichotomous and continuous response [116].

Dichotomous response could come up with 2 types such as the study on acute toxicity with laboratory animals. The response could come up as “dead” or “undead,” or when studying on tumor formation, it could come up with “with” or “without” tumour, for example [116].

Continuous response is the assessment of response in terms of severity level such as liver enzyme which has been found in the blood stream showing the severity of the liver having been destroyed by the threats [116].

Response could come up with dichotomous and continuous types. In reality, such two cases could occur together. The assessment on response could come up with “dead” or “undead” and fine out further how much the destroying level the undead group has had. The assessment of these two types of response could be done at the same time along each other [116].

Besides responding to the size of being exposed to, there are other factors affecting the response and should be taken into consideration. These are duration of exposure, degree of reversibility, time of responses, type of responses, site of responses, and genetic factors [116].

1.4.7.7 Risk characterization

Risk assessment for hazard quotient (HQ) that calculated according to the following equation [123,124]:

$$HQ = \text{Exposure (mg/kg/day)} / \text{RfD (mg/kg/day)}$$

Where HQ represents risk characterization, reference dose (RfD) of PM_{10} (0.011 mg/kg/day) and RfD of silica (0.003 mg/kg/day).

An HQ>1 was considered risk health effects from exposure while HQ≤1 was considered acceptable level

1.4.8 Theoretical of conceptual framework

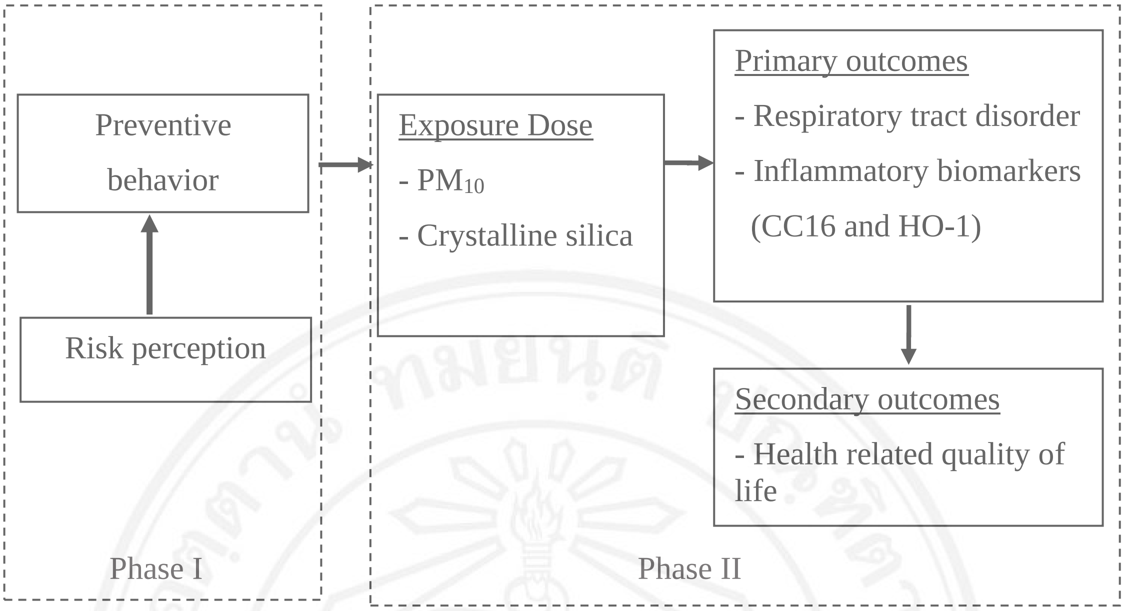


Figure 1.1 Theoretical of conceptual framework

A theoretical of conceptual framework aimed to identified the dose-response association of respirable dust exposure with respiratory disorders and biomarkers among stone-mortar workers (SMW), and was to assess the risk perception of crystalline silica exposure, preventive behavior, and HRQOL in SMW and people living around stone-mortar factories (Figure 1.1).

1.5 Scope of the study

This study was a retrospective cohort and cross-sectional study which conducted the study among SMW who worked at 11 stone-mortar factories currently in operation and people living around stone-mortar factories in two villages in Bansang Sub-District, Phayao Province, Thailand during January and March 2017.

1.6 Expected benefits from the study

This research can create awareness and modify behavior of SMW and people living around stone-mortar factories. In addition, this research can provide a guideline for surveillance in exposure to PM_{10} and crystalline silica such as health checking of respiratory tract system in SMW and people living around stone-mortar factories.

1.7 Operatinal definitions

1.7.1 Risk perception refers to level of air quality perception in stone-mortar workers and people living around stone-mortar factories which it has affects to change in self-protective behavior to avoid health risks from PM_{10} and crystalline silica using risk perception questionnaire which consisted of 22 items with four subscales (never, occasionally, often, and always perceived) to assess risk perception.

1.7.2 Preventive behavior refers to any behavior undertaken by stone-mortar workers and people living around stone-mortar factories who believes himself to be healthy for the purpose of preventing or detecting illness in exposure to PM_{10} and crystalline silica using preventive behaviour questionnaire which consisted of 3 part; wearing personal protective equipment (PPE) when exposed air pollution. knowledge and environmental management.

1.7.3 PM_{10} refers to particulate matter less than ten micrometers in diameter.

1.7.4 Crystalline silica refers to an essential component of materials made up of silicon and oxygen (SiO_2) which have an abundance of uses in stone-mortar factories and are vital in stone-mortar products. Occupational exposure to crystalline silica in stone-mortar factories leads to silicosis.

1.7.5 Respiratory tract disorder refers to occupational exposure to crystalline silica in stone-mortar factories leads to respiratory tract disorder such as respiratory symptom following the standardized the American Thoracic Society Division of Lung Diseases (ATS-DLD-78A), pulmonary function following the standard method of the American Thoracic Society (ATS), and chest radiographs finding with silicosis following ILO guidelines.

1.7.6 Clara cell protein 16 (CC16) refers to a 16-kDa protein released due to damage to clara cells found mainly in the lung of stone-mortar workers. The serum CC16 probably reflect the very early toxic effects of crystalline silica particles on the respiratory epithelium.

1.7.7 Heme oxygenase-1 (HO-1) refers to a rate-limiting enzyme in heme catabolism, has antioxidative, antiapoptotic and anti-inflammatory activities which it is a potential biomarker of chronic silicosis, attenuates silica-induced lung injury of stone-mortar workers.

1.7.8 Health related quality of life (HRQOL) refers to HRQOL in stone-mortar workers and people living around stone-mortar factories which HRQOL is a multi-dimensional concept using the SF-36 questionnaire contains 36 questions categorized into a physical component summary (PCS) and a mental component summary (MCS). The SF-36 measures eight health concepts: physical functioning (PF), role limitations due to physical health (RP), bodily pain (BP), general health (GH), vitality (VT), social functioning (SF), role limitations because of emotional problems (RE) and mental health (MH).

CHAPTER 2

METHODOLOGY

This research had two phases of the study processes which first phases was identified the dose-response association of respirable dust exposure with respiratory disorders and biomarkers among stone-mortar workers (SMW), and second phases was to assess the risk perception of crystalline silica exposure, preventive behavior, and health related quality of life (HRQOL) in SMW and people living around stone-mortar factories. The research design of this study was a retrospective cohort and cross-sectional study which conducted the study among SMW who worked at 11 stone-mortar factories currently in operation and people living around stone-mortar factories in two villages in Bansang Sub-District, Phayao Province, Thailand during January and March 2017. The study was approved by the Research Ethics Committee of Faculty of Medicine, Chiang Mai University, Thailand (No. 243/2016). The steps and details of this study were as following:

2.1 Phase 1: Dose-response relationship between respiratory dust exposure, respiratory disorders and biomarkers

A retrospective cohort study was conducted to examine the dose-response relationship between respiratory dust exposure, respiratory disorders and biomarkers which conducted the study among SMW who worked at 11 stone-mortar factories currently in operation as following:

2.1.1 Study design and sample

This phase of the study conducted with a retrospective cohort in two villages in Bansang Sub-District, Phayao Province, Thailand during January and March 2017. Seventy-seven workers consisting of 57 stone-mortar workers that were all available SMW exposed to crystalline silica, and 20 of control group who were age and sex matched, who were agricultural workers in these villages, were recruited. Fifty-seven SMW were conducted, which consisted of 29 stone cutters and 28 stone grinders.

2.1.2 Data collection

The processes of data collection as following:

2.1.2.1 Sending a letter of introduction to SMW and people living around stone-mortar factories in Bansang Sub-District, Phayao Province, Thailand, Phayao hospital, Ban Sang subdistrict municipality, Ban Sang Tambon health promoting hospital, and community leaders requesting for permission to undertake in the providing information and data collection in the study area.

2.1.2.2 Training three student to be research assistant for data collection and questionnaires.

2.1.2.3 Explain the questionnaire (general data, and respiratory symptoms), blood sample collection, pumonary function test, chest radiographs, the collection of particulate matter less than ten micrometers in diameter (PM_{10}) concentrations and signing consent form to SMW and people living around stone-mortar factories.

2.1.2.4 Signing consent form for participation in the research.

2.1.2.5 Interviewing the study subjects, PM_{10} concentration measurement, blood sample collection, pumonary function test, and chest radiographs in SMW and people living around stone-mortar factories.

2.1.2.6 Analysing the concentration of PM_{10} and crystalline silica using visible absorption spectrophotometry by research assistant.

2.1.2.7 Analysing the level of serum clara cell protein 16 (CC16) and heme oxygenase-1 (HO-1) concentrations using enzyme-linked immunosorbent assays (ELISA) kits by research assistant.

2.1.2.8 Analysing pulmonary function results by physician.

2.1.2.9 Analysing chest radiographs and interpreted according International Labour Organization (ILO) guidelines by physician.

2.1.2.10 Recording the data by researcher into computer with the R program, version 3.2.2 for analysis.

2.1.3 Data measurement and instrument tools

The instruments and measures consisted of PM_{10} and crystalline silica exposure, respiratory symptoms, CC16 and HO-1 detection, pulmonary function test, chest radiography and global positioning system (GPS) tool were as follows:

2.1.3.1 PM_{10} and crystalline silica exposure measurement

The collection of PM_{10} was performed by personal sampling following the National Institute for Occupational Safety and Health (NIOSH) method 0600 guides for respirable particulates not otherwise regulated as following NIOSH (1998) [125]. The cyclone (respirable dust nylon cyclone, SKC, UK) and Poly Vinyl Chloride (PVC) filter holders were mounted in the vests of the workers' breathing zone. Ambient air was pumped through a size-selective cyclone at a flow of 1.7 L/min, which was calibrated using a soap bubble meter.

We tested for PM_{10} exposure and crystalline silica exposure in each subject using a personal sampling pump (SKC Inc., USA) with a filter cassette containing a 37 mm PVC filter screening particulate matter down to 5.0 µm with a flow rate of 1.7 liters/minute for an 8-hour work day period, the PVC filter was weighed and then the PVC filter was weighed before and after sampling to analyze the dust concentration using NIOSH method 0600 as following NIOSH (1998) [125].

The crystalline silica concentration was determined using the NIOSH method 7601 as following NIOSH 2003 [126], with a visible absorption spectrophotometer. The concentration of PM_{10} and crystalline silica were expressed for an 8-hour time-weighted average (TWA) as following the Occupational Safety and Health Administration (OSHA) (2018) [127].

2.1.3.2 Risk assessment of PM_{10} and silica exposure

The concentration of PM_{10} and crystalline silica were expressed as eight-hour TWA as following OSHA (2018) [127]. The Average Daily Dose (ADD) was assessed for subjects to PM_{10} and crystalline silica using the United States Environmental Protection Agency (US EPA) in inhalation exposure assessor algorithm. The data was based on the contaminant concentration (C), inhalation rate (IR), exposure time (ET), exposure frequency (EF), and exposure duration (ED) divided by the product of averaging time (AT) and body weight (BW) [123,124] as following:

$$ADD\ (PM_{10}, \text{Silica}) = (C \times IR \times ET \times EF \times ED) / (BW \times AT)$$

where ADD represents average daily dose (mg/kg/day), C=contaminant concentration in air (mg/m^3), IR=inhalation rate ($0.83\ m^3/hrs$), ET=the exposure time (hrs/day), EF=exposure frequency (days/year), ED=exposure duration (years), BW=body weight (kilogram), and AT=the average time (days).

We assessed the health risk of PM_{10} and crystalline silica with a health quotient (HQ), the ratio of the potential exposure to a substance using Ministry of Public Health and the US EPA's principal approach to and rationale for assessing risk for health effects other than cancer and gene mutations from chronic chemical exposure. We calculated the HQ according to the following equation [123,124]:

$$HQ = \text{Exposure (mg/kg/day)}/\text{Reference dose (RfD) (mg/kg/day)}$$

where HQ represents risk characterization, RfD of PM_{10}= 0.011 mg/kg/day, RfD of silica = 0.003 mg/kg/day).

An HQ>1 was considered risk health effects from exposure while HQ≤1 was considered acceptable level

2.1.3.3 Respiratory symptoms

The respiratory symptoms questionnaire used in the interviews included respiratory symptoms following the standardized the American Thoracic Society Division of Lung Diseases (ATS-DLD-78A) which consist of 7 symptoms were coughing, phlegm, coughing with phlegm, wheezing, difficulty in breathing, chest pain, and past illness included ask other questions such as nose irritation and stuffy nose following Helsing et al. (1979) [128].

2.1.3.4 Pulmonary function test

We used a spirometer (MicroLab 3500 Spirometer, UK) to determine forced expiratory volume in one second (FEV_1), forced vital capacity (FVC), and ratio of Force expiratory volume in one secon/ forced vital capacity (FEV_1/FVC) following the standard method of the American Thoracic Society (ATS) and Miller et al. (2005) [129]. The average percent predicted for each pulmonary function test was calculated after measurement and compared to the healthy Thai population following Dejsomritrutai et al. (2000) [130].

The findings were interpreted by comparison with percentages predicted for normal people sharing the same height, age, sex, and ethnic background. Standard values of pulmonary function were compared with the gold standard following the standard method of the ATS and Miller et al. (2005) [129]. Obstructive airway disease was defined as a FEV_1/FVC value below the fifth percentile for the predicted value; restrictive lung disease was defined as a FVC value below the fifth percentile for the predicted value with a normal FEV_1/FVC value; mixed airway disease was defined as a reduction in the FEV_1/FVC value; and a FVC value below the fifth percentile for the predicted value following Pellegrino et al. (2005) [131].

2.1.3.5 Chest radiographs

Chest radiographs were taken for each subject at Phayao Hospital and interpreted by a physician from the Central Chest Institute of Thailand following ILO guidelines, (2011) [75].

2.1.3.6 Clara cell protein 16 (CC16) and heme oxygenase 1 (HO-1) detection

Venous blood samples from all the subjects were drawn. To obtain serum, the blood was then centrifuged at 4000 rpm for minutes, and serum was transferred to a one ml sterile microcentrifuge tube, and then stored at -80 °C. Serum CC16 and HO-1 concentrations were measured by using ELISA kits according to the recommendations of the supplier (Bio vendor®, Czech Republic, and Cusabio®, China).

2.1.4 Data and statistics

2.1.4.1 Association of exposure PM_{10}, crystalline silica and respiratory symptoms and pulmonary function

The collected data were analyzed using the R program, version 3.2.2 following R Development Core Team (2013) [132]. The Chi-square, Fisher's exact and Kruskal-wallis tests were used to compare demographic characteristics (age, sex, education level, duration of exposure and mask used while working); social habits (smoking and alcohol use); medical history (history of underlying disease, respiratory symptoms, pulmonary function test results, chest radiographic findings); and the amount of PM_{10} and crystalline silica collected. Multiple Linear Regression analysis was used to analyze the association between the exposure levels to PM_{10}, crystalline silica and pulmonary function. Statistical significance was set at $p<0.05$.

2.1.4.2 Assocoation of exposure PM_{10} and crystalline silica concentration with serum CC16 and HO-1 levels

All data analyses were performed with the R program, version 3.2.2 following R Development Core Team (2013) [132]. Demographic data (sex, age and living duration), current smoker, exposure duration, wearing a mask while working, clinical characteristics (body mass index (BMI) and pulmonary function test), and co-morbidity were tested by using mann-whitney u test and chi-square test. The correlation between characteristics, silica concentrations and pulmonary functions by using Spearman's rank correlation test, and mann-whitney u test. Additionally, the association of crystalline silica concentration with serum CC16 and HO-1 levels by multiple regression analysis**.** Statistical significant in this study was defined as a $p<0.05$.

2.1.5 Inclusion and exclusion criteria

2.1.5.1 Inclusion criteria for 57 SMW from 11 stone factories which all available SMW were those who must have worked at their jobs for at least 1 year. Our study also included a control group which consisted of 20 agricultural workers who were age and sex matched with the study subjects. All subjects were aged at least 18 years. People living around stone-mortar factories which have lived at the study area for at least 1 year.

2.1.5.2 Exclusion criteria for SMW which did not participate in this research and controls were those unable to communicate in the Thai language, those having neuropathy and agree to sign consent form.

2.2 Phase 2: Risk perception, preventive behaviors and health related quality of life in stone-mortar workers and people living around stone-mortar factories

We had 2 studies which consist of the study of risk perception and preventive behaviors in SMW and people living around stone-mortar factories because we would like to study characteristics of risk perception and preventive behaviors in PM_{10} and crystalline silica exposure from stone-mortar factories and the second was the study of quality of life in SMW and people living around stone-mortar factories because we would like to study HRQOL characteristic in PM_{10} and crystalline silica exposure from stone-mortar factories as following.

2.2.1 Study design and sample

The study was conducted among all available SMW. Fifty-seven subjects participated from a total population of 59 who were willing to participate, which collected the data from 11 home stone factories and three hundred twenty-five subjects of people living around stone-mortar factories. The research was studied between January and March 2017 in Ban Sang Sub-District, Phayao Province, Thailand.

2.2.1.1 The study of risk perception and preventive behaviors

The data of risk perception, preventive behavior and HRQOL in SMW was collected the data from SMW currently in operation at 11 home stone-mortar factories. Fifty-seven subjects participated from a total population of 59 people. The study was conducted among all available SMW who were willing to participate, which consisted of 29 stone cutters and 28 stone grinders.

Moreover, three hundred twenty-five subjects participated from a total population of 866 people which were studied risk perception and preventive behavior in people living around stone-mortar factories. A simple random sampling method was used, and sample size was calculated for estimating the proportion of a finite population. We selected 325 subjects (37.5%) of a total population of 866 people.

The formula for sample size calculation based on the proportion of air pollution risk perception and preventive behavior was eligible further analysis at 48% following Omanga et al. (2014) [49]. The n4Studies was used for sample size calculation following Ngamjarus, 2016) [133,134] 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 = 0.48

Delta = 0.048

Alpha = 0.05, Z (0.975) = 1.960

n (sample size) = 282

We added at least 15% to the estimated sample size to allow for losses. Therefore, the sample size needed to be 325 subjects.

2.2.1.2 The study of HRQOL

Three hundred eighty subjects participated from a total population of 866 people which were studied HRQOL of crystalline silica exposure. A simple random sampling method was used, and sample size was calculated for estimating the proportion of a finite population. We selected 380 subjects (43.9%) of a total population of 866 people.

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 HRQOL at 29.5 % following D'Souza et al. (2013) [65]. The sample size calculation using n4Studies following Ngamjarus (2016) [133,134] was 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. The data was not completed 12 subjects. Therefore, the sample size needed to be 380 subjects.

2.2.2 Data collection

The process of data collection as following:

2.2.2.1 Sending a letter of introduction to SMW and people living around stone-mortar factories in Bansang Sub-District, Phayao Province, Thailand, Phayao hospital, Ban Sang subdistrict municipality, Ban Sang Tambon health promoting hospital, and community leaders requesting for permission to undertake in the providing information and data collection in the study area.

2.2.2.2 Training three student to be research assistant for data collection and questionnaires.

2.2.2.3 Explain the questionnaire (general data, risk perception, and SF-36), and signing consent form to SMW and people living around stone-mortar factories.

2.2.2.4 Signing consent form for participation in the research.

2.2.2.5 Interviewing the study subjects with questionnaire in SMW and people living around stone-mortar factories.

2.2.2.6 Recording the data by researcher into computer with the R program, version 3.2.2 for analysis.

2.2.3 Data measurement and instrument tools

The instruments and measures consisted of the risk perception, preventive behavior of crystalline silica exposure, HRQOL questionnaires and GPS tool were as follows:

2.2.3.1 Risk perception questionnaire

Risk perception was measured using a questionnaire for original use in France which was translated into the Thai language with the contents synthesized from the forward and backward translations with content validity. The original air quality perception scale was tested for validity and reliability by Deguen et al. (2012) [89]. The reliability was 0.801. It contains 22 items with four subscales (never, occasionally, often, and always perceived) to assess risk perception (anxiety about health and quality of life) and the extent to which air pollution is a nuisance (sensorial perception and symptoms). Scores of at least 22 indicated a poor risk perception or a high level of risk perception while the scores lower than 22 indicated a good risk perception or a low level of risk perception following Deguen et al. (2008) and Deguen et al. (2012) [89,95].

2.2.3.2 Preventive behaviour questionnaire

Preventive behaviour questionnaire was tested for content validity and reliability. The reliability was 0.834. It contains 14 items with five subscales (never, occasionally, sometime, often, and always) to assess preventive behaviour. The questionnaire was consisted of 3 parts; wearing personal protective equipment (PPE) while working had 6 items; knowledge had 4 items and environmental management 4 items.

2.2.3.3 Health related quality of life (HRQOL) questionnaire

The 36-item short form survey (SF-36) is a standard or generic questionnaire for assessing HRQOL which has been used extensively worldwide. This questionnaire was made into the form of a manual by Ware et al. (1994; 1995; 1998) [108,135,136], and the SF-36 version 2 was translated into Thai by Jirarattanaphochai et al. (2005) [137]. The SF-36 questionnaire contains 36 questions categorized into two main components, specifically a physical component summary (PCS) score and a mental component summary (MCS) score. The SF-36 measures eight health concepts: 1) physical functioning (PF) (10 items); 2) role limitations due to physical health (RP) (4 items); 3) bodily pain (BP) (2 items); 4) general health (GH) (5 items); 5) vitality (VT) (4 items); 6) social functioning (SF) (2 items); 7) role limitations because of 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 HRQOL. The scores assigned to all question items can be categorized for computation of total component score, specifically PCS and MCS.

2.2.3.4 Global positioning system (GPS) Tool

The geographic positions or coordinates of the stone-mortar factories and those of people living around 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 quantum geographic information system (QGIS) program.

2.2.4 Data and statistics

2.2.4.1 Risk perception, preventive behavior and HRQOL in stone-moratar workers

Risk perception and preventive behavior were analyzed using the R program, version 3.2.2 following R Development Core Team (2013) for descriptive statistics on frequencies, means, standard deviations (SD), were used to describe the sample [132]. Factors associated with risk perception were analyzed by Chi-square test. Statistical significance was taken as a $p<0.05$.

HRQOL was analyzed using the R program, version 3.2.2 following R Development Core Team (2013) for descriptive statistics on characteristics of participants, medical history, smoking and alcohol use and HRQOL scores. These data were analyzed by Mann-Whitney U test and Kruskal-Wallis test [132].

2.2.4.2 Risk perception, preventive behavior and HRQOL in people living around stone-mortar factories.

Descriptive statistics such as frequencies, means and standard deviation (SD) were used to describe the sample for risk perception and preventive behavior. Factors associated with risk perception were analyzed by Binary logistic regression analysis. The association between distances and respiratory symptoms was analyzed by Multiple logistic regression. The confounders were adjusted in terms of age, education, smoking, number of respiratory symptoms and underlying disease, and distance from stone factories. Statistical significance was taken as a $p<0.05$.

HRQOL was analyzed using the R program, version 3.2.2 following R Development Core Team (2013) 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 people living around stone-mortar factories were analyzed by Multivariate regression analysis.

2.2.5 Inclusion and exclusion criteria

2.2.5.1 Inclusion criteria for 57 stone-mortar workers from 11 stone factories which all available SMW were those who must have worked at their jobs for at least 1 year. Our study also included a control group which consisted of 20 agricultural workers who were age and sex matched with the study subjects. All subjects were aged at least 18 years.

2.2.5.2 Exclusion criteria for SMW and people living around stone-mortar factories which used exclusion criteria as phase I.

CHAPTER 3

RESULTS

This research has four objectives which consisting of 1) to assess the concentration of particulate matter less than ten micrometers in diameter (PM_{10}) and crystalline silica among stone-mortar workers (SMW); 2) to identify the respiratory disorders among SMW and people living around stone-mortar factories; 3) to examine the dose-response relationship between PM_{10}, crystalline silica dust and respiratory disorders, with serum clara cell 16 (CC16) and heme oxygenase-1 (HO-1) levels among SMW, and 4) to assess the risk perception and preventive behaviors of crystalline silica dust exposure, and health related quality of life (HRQOL) in SMW and people living around stone-mortar factories. The results of this study divided into 7 parts as following;

3.1 Community context and the stone-mortar factory process

3.2 Baseline characteristics of the study participants

3.3 PM_{10} containing crystalline silica exposure level

3.4 Respiratory disorders among stone-mortar workers and people living around stone-mortar factories

3.5 Risk perception and preventive behaviors of crystalline silica exposure

3.6 Health related quality of life in stone-mortar workers and people living around stone-mortar factories.

3.7 Dose-response relationship between dust exposure, respiratory disorders and inflammatory markers among stone-mortar workers

3.1 Community context and the stone-mortar factory process

This study has shown that community context and the stone-mortar factory process consisted of 1) location of the study area and stone-mortar factories in the community, and 2) the process of stone-mortar production as following:

3.1.1 Location of the study area and stone-mortar factories in the community

We conducted a cross-sectional study among workers at 11 home stone-mortar factories from January to June 2017 in two villages in Ban Sang Subdistrict of Phayao Province, Thailand (UTM zone 47Q east: 0587424 north: 2119035) (Figure 3.1A) where 11 stone-mortar factories are operating (Figure 3.1B).

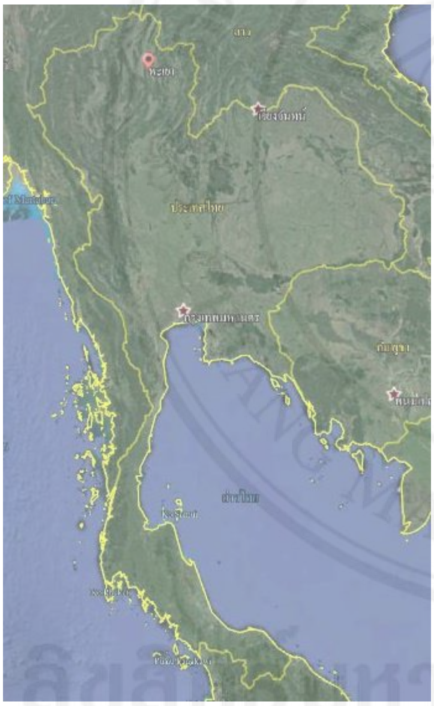


Figure 3.1A Location map of study area in Phayao Province, Thailand

Figure 3.1B Location map of 11 home stone factories in the study area; = stone factories

3.1.2 The process of stone-mortar production

The home stone-mortar factories consist of four processes: raw material, stone cutting, stone grinding and finished products. However, the main processes of home stone-mortar factories were divided into two types: stone cutting and stone grinding. In the stone cutting sector, workers cut and roughly shape stone. In stone grinding, the workers turn and smooth the stone-mortars with a lathe (Figure 3.2).

A. Stone cutting sector

B. Stone grinding sector

Figure 3.2 Stone-mortar factory showing the two separate sectors:

(A) The stone cutting sector (B) The stone grinding sector

3.2 Baseline characteristics of the study participants

This study has shown that baseline characteristics of SMW and people living around stone-mortar factories which baseline characteristics consisted of 1) baseline characteristics of SMW and control groups, and 2) baseline characteristics of people living around stone-mortar factories as following:

3.2.1 Baseline characteristics of stone-mortar workers and control groups

Fifty-seven subjects of this study were recuired from a total 59 populations of SMW. The baseline characteristics of study subjects are summarized in Table 3.1. A total of 20 controls were included in the study. Ninety-one percent of stone-mortar worker subjects were males. Ninety percent of stone cutter study subjects were males. The mean age of SMW was 46.9 years. The mean exposure duration of SMW was 21.7 years. The mean age of stone cutter study subjects was 47.9 years. The mean exposure duration of stone cutters were 22.7 years. Ninety-three percent stone grinder study subjects were males. The mean age of stone grinder study subjects was 45.8 years. The mean mean exposure duration of stone grinders were 20.8 years. Seventy-five percent of control subjects were males. The mean age of control subjects was 47.3 years.

The numbers of subjects with underlying disease among stone cutters, stone grinders and controls were 5, 5 and 2, respectively. The co-morbidity present among stone cutters were hypertension (n=3), diabetes mellitus (n=1) and both diabetes mellitus and hypertension (n=1). The underlying disease present among stone grinders were asthma (n=2), hypertension (n=1), diabetes mellitus (n=1) and both hypertension and asthma (n=1). The co-morbidity present among controls were hypertension (n=1), and diabetes mellitus (n=1) (data not shown).

The demographic characteristics, including age, sex, living duration, education levels, duration of exposure, current smokers, pack-years smoked, alcohol user, co-morbidity and body mass index (BMI) were not significantly different between stone-mortar workers and control groups. There were no significant differences among stone cutters, stone grinders, and control subjects in terms of demographic characteristics, including age, sex, living duration, education levels, duration of exposure, current smokers, pack-years smoked, alcohol user, underlying disease and BMI.

Table 3.1 Baseline characteristics of stone-mortar workers and control groups

Characteristics	SMW (n=57)	Stone-mortar position		Controls (n=20)
		Stone cutters (n=29)	Stone grinders (n=28)	
1. Mean age in years (±SD)[1,a,b]	46.9±12.6	47.9±13.2	45.8±12.0	47.3±11.2
2. Sex[2,c,d]				
Male	52 (91.2)	26 (89.7)	26 (92.9)	15 (75.0)
Female	5 (8.8)	3 (10.3)	2 (7.1)	5 (25.0)
3. Living duration[1,a,b], years	44.2±16.2	45.4 (16.8)	42.9 (15.8)	45.6±12.9
4. Education level[2,c]				
≤Primary School	34 (59.6)	15 (52)	19 (68)	8 (40)
>Primary School	23 (40.4)	14 (48)	9 (32)	12 (60)
5. Mean duration of exposure in years (±SD)[1,a]	21.7±16.9	22.7±17.1	20.8±16.9	-
6. Current smokers[2,c]	26 (45.6)	12 (41.4)	14 (50.0)	7 (35.0)
7. Mean pack-years smoking(±SD)[1,a,b]	4.5±6.4	5.3±10.6	6.8±10.1	2.7±5.2
8. Alcohol user[1,a,b]	39 (68.4)	21 (72)	18 (64)	12 (60)
9. Underlying disease[2,c]	10 (17.5)	5 (17)	5 (18)	2 (10)
10. BMI[1,a,b], Kg/m^2	22.5±4.2	22.1±3.8	22.8±4.7	23.1±3.3

[a]Presented in Mann-Whitney U test, [b]Kruskal-Wallis test, [c]Chi-square test, [d]Fisher's exact test; *p<0.05

[1]Data are presented as mean±standard deviation (SD)

[2]Data are presented as the absolute number and percentage of subjects

3.2.2 Baseline characteristics of people living around stone-mortar factories

A total of 325 subjects for the study of risk perception and preventive behaviors from the total 866 populations. Gender of the subjects were male 155 (47.7%) and females 170 (52.3%). The average age was 56.1 years old with an average income of 4,154.2 baht per month. The average length of living in this community was 52.7 years. The sample populations who had no respiratory symptoms or underlying diseases were 45.8% and 64.0% respectively. The average distance between residential home and stone-mortar factories was 97.6 meters. The proportion of residential home distance within 100 meters was 85.27%.

A total of 380 subjects for the study of quality of life from the total 866 people. Among the subjects, 158 (41.6%) were males and female 222 (58.4%). The average age was 55.6 years old with an average income of 4,274.2 baht per month. The average length of living in this community was 52.4 years. The sample populations who had no respiratory symptoms or underlying diseases were 48.2% and 64.8% respectively. The average distance between residential home and stone-mortar factories was 96.3 meters. The proportion of residential home distance within 100 meters was 51.3% (Table 3.2).

Table 3.2 Baseline characteristics of people living around stone-mortar factories

Characteristics	Study of risk perception (n=325), n (%)	Study of quality of life (n=380), n (%)
1. Sex[a]		
Female	170 (52.3)	222 (58.4)
Male	155 (47.7)	158 (41.6)
2. Age, mean±SD	56.1±15.3	55.6±15.3
≥60	125 (38.5)	138 (36.3)
46-59	141 (43.4)	169 (44.5)
≤45	59 (18.2)	73 (19.2)

Table 3.2 (Continued)

Characteristics	Study of risk perception (n=325), n (%)	Study of quality of life (n=380), n (%)
3. Income (baht/month), mean±SD	4154.2±5974.9	4274.2±5574.4
≤1,000	126 (38.8)	148 (38.9)
1,001-4,000	95 (29.2)	98 (25.8)
≥4,001	104 (32.0)	134 (35.3)
4. Education		
≤Primary school	240 (73.8)	286 (75.3)
>Primary school	85 (26.2)	94 (24.7)
5. Marital status		
Single	50 (15.4)	59 (15.5)
Married	237 (72.9)	285 (75.0)
Divorce	38 (11.7)	36 (9.5)
6. Occupation		
Daily hired workers	146 (44.9)	167 (43.9)
Agriculture	93 (28.6)	95 (25.0)
Unemployed	70 (21.5)	93(24.5)
Company and government employee	9 (2.8)	19 (5.0)
Students	7 (2.2)	5 (1.3)
7. Type of occupation		
Light labor	82 (25.2)	109 (28.7)
Moderate labor	150 (46.2)	176 (46.3)
Heavy labor	93 (28.6)	95 (25.0)
8. Smoker		
No	264 (81.2)	322 (84.7)
Yes	61 (18.8)	58 (15.3)

Table 3.2 (Continued)

Characteristics	Study of risk perception (n=325), n (%)	Study of quality of life (n=380), n (%)
9. Alcohol user		
No	238 (73.2)	280 (73.7)
Yes	87 (26.8)	100 (26.3)
10. Number of respiratory symptoms[b]		
None	149 (45.8)	183 (48.2)
1-2	75 (23.1)	91 (23.9)
≥3	101 (31.1)	106 (27.9)
11. Numberof underlying diseases		
None	208 (64.0)	245 (64.5)
1	76 (23.4)	88 (23.2)
≥2	41 (12.6)	47 (12.4)
12. Length of living in this community (years), mean±SD	52.7±18.3	52.4±18.3
13. Residential distance from stone-mortar factories (meters),		
mean±SD	97.6±39.2	96.3±40.3
>100	48 (14.8)	185 (48.7)
51-100	109 (33.5)	136 (35.8)
≤50	168 (51.7)	59 (15.5)

3.3 PM_{10} containing crystalline silica exposure level

This study has shown that the exposure level of PM_{10} containing crystalline silica in SMW and people living around stone-mortar factories consisted of 1) PM_{10} and crystalline silica concentrations in SMW, and 2) the correlation between PM10 and crystalline silica concentrations for an eight-hour time-weighted average (TWA) as following:

3.3.1 PM_{10} and crystalline silica concentrations in stone-mortar workers

In our study, SMW (0.350±0.468 mg/m^3) had significantly (p<0.001) greater PM_{10} levels than controls (0.033±0.021 mg/m^3). Moreover, stone cutters (0.029±0.296 mg/m^3) and stone grinders (0.416±0.596 mg/m^3) had significantly (p<0.001) higher PM_{10} levels than controls (0.033±0.021 mg/m^3), but PM_{10} levels in all subjects did not exceed the standard level of the American Conference of Governmental Industrial Hygienists (ACGIH) guidelines (3 mg/m^3) and Hearl, (1998) [138]. In addition, SMW (0.112±0.100 mg/m^3) had significantly greater (p=0.000) silica levels than controls (0.004±0.005 mg/m^3). Moreover, stone cutters (0.096±0.094 mg/m^3) and stone grinders (0.130±0.106 mg/m^3) had significantly higher (p=0.000) silica levels than controls (0.004±0.005 mg/m^3). Silica levels in the stone cutters and stone grinders was higher than the standard level of ACGIH guidelines (0.025 mg/m^3) and Hearl (1998) [138] (Table 3.3).

The average daily dose (ADD) of PM_{10} and crystalline silica in SMW were 0.018 and 0.005 mg/kg-day, respectively. Risk characterization with health quotient (HQ) of PM_{10} and crystalline silica in stone-mortar workers were 1.64 and 1.67, respectively which an HQ>1 was considered risk health effects from exposure following by Ministry of Public Health and the United States Environmental Protection Agency (US EPA) [123,124] (Table 3.4).

Table 3.3 Concentrations of PM_{10} and crystalline silica collected in 8-hr TWA hours among study subjects

Subject Group	Eight-hour TWA in mg/m³			
	PM_{10} concentration		Crystalline silica concentration	
	mean±SD	min-max	mean±SD	min-max
Stone-mortars[a] (n=57)	0.350±0.468*	0.045-2.706	0.112±0.100*	0.003-0.453
- Stone cutters[b] (n=29)	0.286±0.296*	0.045-1.253	0.096±0.094*	0.003-0.316
- Stone grinders[c] (n=28)	0.416±0.596*	0.050-2.706	0.130±0.106*	0.024-0.453
Control group[d] (n=20)	0.033±0.021	0.010-0.087	0.004±0.005	0.001-0.022

*p<0.01; [ad]Stone-mortars compared with control group, [bd]Stone cutters compared with control group, [cd]Stone grinders compared with control group

Table 3.4 Crystalline silica and PM_{10} concentrations and HQ among stone-mortar workers and control groups

Subjects	PM_{10} concentration					Crystalline silica concentration				
	8-hr TWA, mg/m^3		ADD, mg/kg-day		HQ[#] 95% CI	8-hr TWA, mg/m^3		ADD, mg/kg-day		HQ[#] 95% CI
	Mean±SD	Min, Max	Mean±SD	Min, Max		Mean±SD	Min, Max	Mean±SD	Min, Max	
SMW (n=57)	0.350±0.468*	0.045, 2.706	0.018±0.038*	0.000, 0.237	1.64 (-5.27-8.55)	0.112±0.100*	0.003, 0.453	0.005±0.008*	0.000, 0.040	1.67 (-3.67-7.00)
Control(n=20)	0.033± 0.021	0.010, 0.087	0.000±0.000	0.000, 0.000	ND	0.003±0.005	0.001, 0.022	0.000±0.000	0.000, 0.000	ND

Presented in Mann-Whitney U test; *p<0.001 compared with control group; not determined (ND); The acceptable level of PM_{10} is less than 3 mg/m^3 8-hr TWA (respirable) and silica is less than 0.025 mg/m^3 8-hr TWA (respirable) according ACGIH; [#]HQ = Exposure concentration (mg/kg-day)/ Reference dose (RfD) (mg/kg-day)

The average concentration of PM_{10} in all stone-mortar factories did not exceed the standard level of the National Institute for Occupational Safety and Health (NIOSH) and ACGIH, while the crystalline silica concentration in all factories were higher than the standard level of NIOSH and ACGIH allowed extent (0.025 mg/m^3) [127] (Table 3.5).

Table 3.5 PM_{10} and crystalline silica concentrations in 11 home stone-mortar factories

Stone factories (n^a=41)	PM_{10} concentration (mg/m^3)		Crystalline silica concentration (mg/m^3)	
	Mean±SD	Min-Max	Mean±SD	Min-Max
Factory 1 (n^a=4)	0.236±0.102	0.110-0.360	0.137±0.050*	0.072-0.194
Factory 2 (n^a=4)	0.092±0.033	0.045-0.120	0.040±0.039*	0.005-0.075
Factory 3 (n^a=2)	0.446±0.289	0.242-0.650	0.263±0.182*	0.134-0.391
Factory 4 (n^a=6)	0.233±0.131	0.136-0.491	0.139±0.095*	0.053-0.316
Factory 5 (n^a=6)	0.902±1.079	0.048-2.706	0.169±0.163*	0.027-0.453
Factory 6 (n^a=2)	0.673±0.845	0.075-1.270	0.150±0.150*	0.044-0.256
Factory 7 (n^a=3)	0.171±0.049	0.122-0.220	0.097±0.039*	0.055-0.131
Factory 8 (n^a=2)	0.213±0.045	0.181-0.244	0.127±0.031*	0.105-0.149
Factory 9 (n^a=5)	0.287±0.142	0.114-0.503	0.170±0.090*	0.060-0.309
Factory 10 (n^a=4)	0.143±0.075	0.050-0.234	0.081±0.052*	0.024-0.151
Factory 11 (n^a=3)	0.103±0.056	0.058-0.166	0.055±0.041*	0.030-0.103

n^a= number of personnel dust samplers for each factory; *Higher than the standard levelof ACGIH; Silica (0.025 mg/m^3) at eight-hour TWA

The mean distance of each stone-mortar factories located remote from other factories (no 1, 2, 3, 4, 8 and 9) was 174.5 meters (Min = 90, Max = 246, mean = 174.5, SD = 65.0). These formed a distribution pattern shown as pattern A in Figure 3.3. The mean distance of stone-mortar factories located nearby to other factories (no 5, 6, 7, 10 and 11) was 68.9 meters (Min = 53.0, Max = 77.0, mean = 68.9, SD = 11.4); pattern B in Figure 3 shown as cluster pattern. The mean PM_{10} concentration of stone-mortar workers in pattern A was greater than that in pattern B (0.261±0.107, and 0.127±0.026 mg/m^3, respectively). The mean crystalline silica concentration of the stone-mortar workers (Pattern A) was greater than Pattern B (0.152±0.066, 0.070±0.016 respectively). The mean concentrations of crystalline silica in both patterns were greater than both NIOSH and ACGIH (0.025 mg/m^3) [127]. The concentrations of PM_{10} and crystalline silica were associated differently in both cluster pattern and distribution pattern of stone-mortar factories locations (p<0.001) (data not shown).

Figure 3.3 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)

3.3.2 The correlation between PM_{10} and crystalline silica concentrations for an eight-hour Time-weighted average

PM_{10} concentration was significantly associated with crystalline silica concentration using linear regressions (Figure 3.4). The linear correlations for each concentration of the variability in the data, as determined by the R^2-value of the regressions (where x is the PM_{10} concentration (mg/m^3) and y is the silica concentration (mg/m^3)).

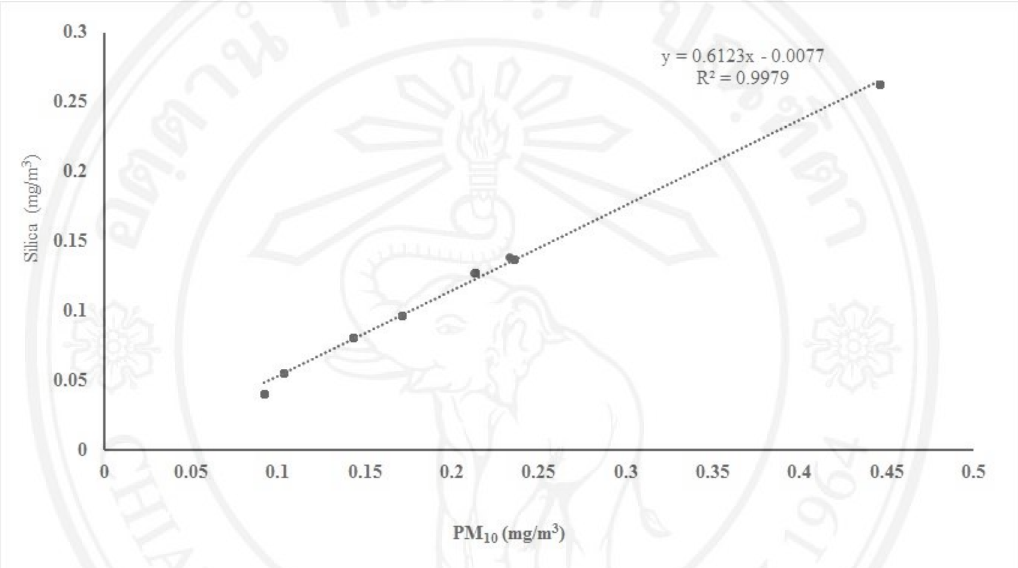


Figure 3.4 Relationship between PM_{10} and crystalline silica concentrations of home stone factories

3.4 Respiratory disorders among stone-mortar workers and people living around stone-mortar factories

This study has shown that the respiratory disorders in SMW and people living around stone-mortar factories consisted of 1) sign and symptoms of respiratoty tract problem among SMW, 2) sign and symptoms of respiratory tract problem among people living around stone-mortar factories, 3) pulmonary function test result and chest rediograph findings among SMW, and 4) respiratory inflammatory marker: serum CC 16 and HO-1 levels as following:

3.4.1 Sign and symptoms of respiratory tract problem among stone-mortar workers

Fifty-seven SMW had respiratory symptoms consisting of coughing (45.6%), phlegm (33.3%), coughing with phlegm (31.6%), and nose irritation (22.8%). Twenty-nine stone cutters had respiratory symptoms consisting of coughing (51.1%), phlegm (37.9%) and coughing with phlegm (32.1%). Twenty-eight stone grinders had respiratory symptoms consisting of coughing (39.3%), coughing with phlegm (32.1%) and phlegm (28.6%). There were significantly more phlegm and coughing with phlegm among SMW than controls. There were significantly more phlegm and coughing with phlegm among stone cutters and stone grinders than controls (Table 3.6).

Table 3.6 Sign and symptoms of respiratory tract problem among stone-mortar workers

Symptoms	SMW[a] (n=57)	Stone-mortar position		Controls[d] (n=20)
		Stone cutters[b] (n=29)	Stone grinders[c] (n=28)	
1. Coughing	26 (45.6)	15 (51.7)	11 (39.3)	5 (25.0)
2. Phlegm	19 (33.3)**	11 (37.9)**	8 (28.6)**	0 (0.0)
3. Coughing with phlegm	18 (31.6)**	9 (31.0)*	9 (32.1)*	0 (0.0)
4. Wheezing	5 (8.8)	3 (10.3)	2 (7.1)	0 (0.0)
5. Difficulty in breathing	3 (5.3)	1 (3.4)	2 (7.1)	0 (0.0)
6. Chest pain	8 (14.0)	4 (13.8)	4 (14.3)	0 (0.0)
7. Nose irritation	13 (22.8)	6 (20.7)	7 (25.0)	1 (5.0)
8. Stuffy nose	12 (21.1)	5 (17.2)	7 (25.0)	2 (10.0)

[a]Presented in Chi-square test, Fisher's exact test; *p<0.05, **p<0.01; [ad]Stone-mortars compared with control group, [bd]Stone cutters compared with control group, [cd]Stone grinders compared with control group

3.4.2 Sign and symptoms of respiratory tract problem among people living around stone-mortar factories

Three hundred twenty-five in people living around stone-mortar factories for air risk perception had respiratory symptoms consisting of coughing (22.2%), phlegm (14.2%), nose irritation (13.8), stuffy nose (12.3), and coughing with phlegm (11.7%) (Table 3.7).

Table 3.7 Sign and symptoms of respiratory tract problem among people living around stone-mortar factories

Symptoms (n=325)	n (%)
1. Coughing	72 (22.2)
2. Phlegm	46 (14.2)
3. Coughing with phlegm	38 (11.7)
4. Wheezing	23 (7.1)
5. Difficulty in breathing	21 (6.5)
6. Chest pain	35 (10.8)
7. Nose irritation	45 (13.8)
8. Stuffy nose	40 (12.3)

3.4.3 Pulmonary function test result and chest rediograph findings among stone-mortar workers

The statistical analysis showed a significant difference in the number of abnormal chest radiographs between the exposed group (stone cutting and stone grinding workers) and the control group (p=0.042). Interestingly, 8 stone-mortar workers had abnormal chest radiographs and 3 individuals, which consisted of 1 worker from the stone cutters and 2 workers from the stone grinders, were interpreted as having silicosis. Two stone grinders had non-specific radiographic abnormalities, one had emphysematous changes and one had cardiomegaly with mild chronic lung changes.

One stone cutter had upper lobe pulmonary fibrosis. As regards cases of pulmonary function testing, 4 workers in the stone cutters presented with an obstructive lung disease, and 2 workers had a restrictive lung disease. Three stone grinders presented with an obstructive lung disease, 3 workers had a restrictive lung disease, and 2 workers had a mixed obstructive/ restrictive lung disease. Among controls, 3 subjects had restrictive lung disease. Some pulmonary function parameters such as forced expiratory volume in one second (FEV_1), forced vital capacity (FVC), and Force expiratory volume in one secon/ forced vital capacity (FEV_1/FVC) ratio in the two groups were not significantly different, except the percent predicted FEV_1/FVC was significantly lower in control group (p=0.015). Abnormal chest radiograph findings consisted of eight cases, which three cases were diagnosed with silicosis (Table 3.8).

Table 3.8 Respiratory conditions among study subjects

Respiratory conditions	SMW[a] (n=57)	Stone-mortar position		Control subjects[d] (n=20)
		Stone cutters[b] (n=29)	Stone grinders[c] (n=28)	
1. Mean pulmonary function test results (±SD)[1,e,f]				
FEV_1 (L)	2.7±0.8	2.6±0.7	2.8±0.8	2.6±0.7
FVC (L)	3.2±0.8	3.1±0.7	3.3±0.9	3.1±0.9
FEV_1/FVC ratio	84.2±10.0	84.7±9.5	83.6±10.5	86.7±5.7
FEV_1 (%predicted)	94.8±23.3	93±24	97±24	96±25
FVC(%predicted)	90.05±19.0	88±18	92±20	88±26
FEV_1/FVC(%predicted)	100.3±11.6*	101±11	100±13	107±7
2. Pulmonary function[2,g]				
Normal	43 (75.4)	23 (79.3)	20 (71.5)	17 (85.0)
Obstructive	7 (12.3)	4 (13.8)	3 (10.7)	0 (0.0)
Restrictive	5 (8.8)	2 (6.9)	3 (10.7)	3 (15.0)
Mixed	2 (3.5)	0 (0.0)	2 (7.1)	0 (0.0)

Table 3.8 (Continued)

Respiratory conditions	SMW[a] (n=57)	Stone-mortar position		Control subjects[d] (n=20)
		Stone cutters[b] (n=29)	Stone grinders[c] (n=28)	
3. Chest radiograph findings[2,g]				
Normal	49 (86.0)	27 (93.1)	22 (78.6)	20 (100.0)
Abnormal	8 (14.0)	2 (6.9)[h]	6 (21.4)[i]	0 (0.0)
- silicosis	3	1	2	0
- upper lobe fibrosis	1	1	0	0
- nonspecific lesion/mild occlusion	1	0	1	0
- emphysematous change	1	0	1	0
- cardiomegaly and mild	1	0	1	0
- chronic lung changes	1	0	1	0

[e]Presented in Mann-Whitney U test, [f]Kruskal-Wallis test, [g] Fisher's exact test; *$p<0.05$

[1]Data are presented as mean±SD

[2]Data are presented as the absolute number and percentage of subjects

FEV_1/FVC(%predicted) = ad, bd, cd = $p<0.05$

Chest radiograph findings =bd, cd = $p<0.05$

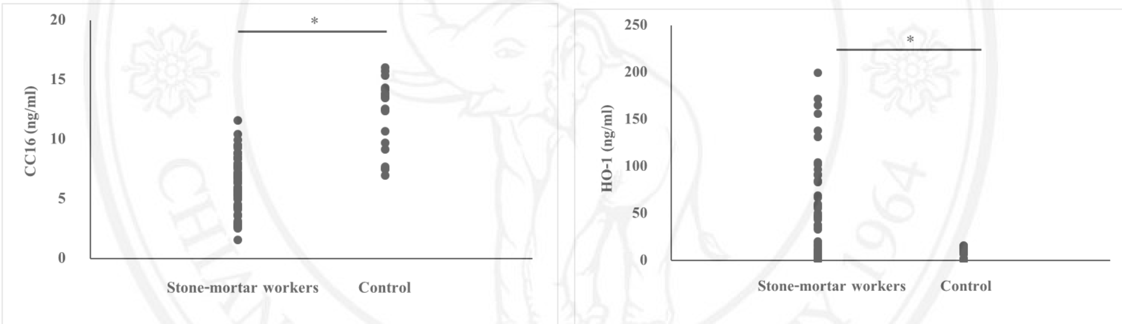
3.4.4 Respiratory inflammatory marker: serum CC 16 and HO-1 levels

The mean±SD of serum CC16 level in SMW was 6.30±2.31 ng/ml, which was significantly lower than those in control group, 12.05±2.95 ng/ml ($p<0.001$) (Figure 3.5A). On the contrary, there was a significantly higher level of serum HO-1 in the SMW group (51.62±46.13 ng/ml) compared with those in the control group (16.01±8.51 ng/ml) ($p<0.001$) (Figure 3.5B). The mean±SD of serum CC16 level in stone cutters and stone grinders were 6.62±2.36 ng/ml and 5.97±2.25 ng/ml, which was significantly lower than those in control group, 12.05±2.95 ng/ml ($p<0.001$). On the contrary, there was a significantly higher level of serum HO-1 in stone cutters (47.73±46.24 ng/ml) and stone grinders (55.64±46.52 ng/ml) compared with those in the control group (16.01±8.51 ng/ml) ($p<0.001$) (Table 3.9).

Table 3.9 Mean±SD of inflammatory biomarkers among stone-mortar workers and control groups

Inflammaotry markers	SMW[a] (n=57)	Stone-mortar position		Control group[d] (n=20)
		Stone cutters[b] (n=29)	Stone grinders[c] (n=28)	
CC 16, ng/ml	6.30±2.31*	6.62±2.36*	5.97±2.25*	12.05±2.95
HO-1, ng/ml	51.62±46.13*	47.73±46.24*	55.64±46.52*	16.01±8.51

[a]Presented in Mann-Whitney U test, [b]Kruskal-Wallis test, t test; *p<0.01 ; [ad]Stone-mortars compared with control group, [bd]Stone cutters compared with control group, [cd]Stone grinders compared with control group



A B

Figure 3.5 Dot plot of serum CC16 levels in stone-mortar workers and control groups, *p<0.001 (A); Dot plot of serum HO-1 levels in stone-mortar workers and control groups, *p<0.001 (B)

3.5 Risk perception and preventive behaviors of crystalline silica exposure

This study has shown that the risk perception and preventive behaviors of crystalline silica exposure in SMW and people living around stone-mortar factories consisted of 1) risk perception of crystalline silica exposure in SMW and people living around stone-mortar factories, 2) factors related with risk perception of crystalline silica exposure in SMW, 3) factors related with risk perception of crystalline silica exposure in people living around stone-mortar factories, and 4) preventive behaviors of crystalline silica exposure in SMW and people living around stone-mortar factories as following:

3.5.1 Risk perception of crystalline silica exposure in stone-mortar workers and people living around stone-mortar factories

There was not significantly level of risk perception in SMW compared with those in the control group (*p*=0.489). Nineteen SMW (33.3%) were found to have a poor risk perception or high-risk perception when compared with those in the control group (25.0%). Seventy-nine of people living around stone-mortar factories (24.3%) were found to have a poor risk perception or high-risk perception (Table 3.10).

Table 3.10 Risk perception of crystalline silica exposure in stone-mortar workers and people living around stone-mortar factories

Subjects	Mean±SD	Min-Max	Risk perception, n (%)	
			<22 scores	≥22 scores
SMW (n=57)	18.6±11.1	0.0-51.5	38 (66.7)	19 (33.3)
Control group (n=20)	17.7±16.2	0.0-69.7	15 (75.0)	5 (25.0)
People living around stone-mortar actories (n=325)	14.4±11.8	0.0-63.6	246 (75.7)	79 (24.3)

Presented in Chi-square test

3.5.2 Factors related with risk perception of crystalline silica exposure in stone-mortar workers

The SMW had awareness of health risks of crystalline silica dust exposure at 33.3% (n=19). Females had a poor risk perception more 40.0% (n=2) than males 32.7% (n=17). Respiratory tract disease had a poor risk perception more (n=18, 46.2%) than non-respiratory tract disorder (n=1, 5.6%). Smoking and respiratory tract diseases were found significantly association with risk perception in SMW (Table 3.11).

Table 3.11 Factors related with risk perception of crystalline silica exposure in stone-mortar workers

Characteristic	Risk perception, n (%)		*p*-value
	<22 Scores n (%), (n = 38)	≥22 Scores n (%) , (n = 19)	
1. Age (years)			
<40	10 (66.7)	5 (33.3)	-
≥40	28 (66.7)	14 (33.3)	
2. Gender			
Male	35 (67.3)	17 (32.7)	0.741
Female	3 (60.0)	2 (40.0)	
3. Education			
≤Primary school	23 (67.6)	11 (32.4)	0.849
>Primary school	15 (65.2)	8 (34.8)	
4. Marital status			
Married	32 (65.3)	17 (34.7)	0.590
Others	6 (75.0)	2 (25.0)	
5. Income per month			
<5,000 Bahts	9 (69.2)	4 (30.8)	0.823
≥5,000 Bahts	29 (65.9)	15 (34.1)	
6. Smoking			
No	13 (52.0)	12 (48.0)	0.038
Yes	25 (78.1%)	7 (21.9)	
7. Alcohol use			
No	12 (66.7)	6 (33.3)	-
Yes	26 (66.7)	13 (33.3)	
8. Respiratory tract disease			
No	17 (94.4)	1 (5.6)	0.003
Yes	21 (53.8)	18 (46.2)	

Presented in Chi-square test

3.5.3 Factors related with risk perception of crystalline silica exposure in people living around stone-mortar factories

Seventy-nine subjects (24.3%) were found to have a poor risk perception or high-risk perception. Demographics and health characteristics associated with the risk perception level were presented in Table 3.12. Subjects' ages between 46 and 59 years and below 45 years had a poorer risk perception than ages over 60 years (crude odd ratio (cOR) 2.2, 95 % confidence interval (CI): 1.2-4.0; cOR 2.2, 95 % CI: 1.1-4.7 respectively). Subject's with incomes at 1,001-4,000 baht/month and >4,001 baht/month had a poorer risk perception than subject's with incomes at ≤1,000 baht/month (cOR 3.4, 95 % CI: 1.7-6.8; cOR 3.6, 95 % CI: 1.8-7.1 respectively). Subjects with moderate labor and heavy labor had a poorer risk perception than light labor (cOR 2.9, 95 % CI: 1.4-6.1; cOR 2.8, 95 % CI: 1.3-6.2 respectively). Subjects who were smokers had a poorer risk perception than non-smokers (cOR 3.0, 95 % CI: 1.6-5.3). For subjects who had more than three respiratory symptoms had a poorer risk perception than those with no symptoms (cOR 2.9, 95 % CI: 1.6-5.0). Interestingly, those with distance from residential home to stone-mortar factories between 51 and 100 meters and lower than 50 meters had a poorer risk perception than those whose distance from residential home to stone-mortar factories more than 100 meters (cOR 1.8, 95 % CI: 1.1-3.0; cOR 2.5, 95 % CI: 1.3-4.9 respectively).

Table 3.12 Binary logistic regression analysis of the relationship between demographics, health characteristics, distance from home to stone factories and risk perception

Variables	n (%)	Risk perception		cOR
		<22 scores n (%), (n=246)	≥22 Scores n (%), (n=79)	(95% CI)
1.Sex[a]				
Female	170 (52.3)	133 (54.1)	37 (46.8)	Ref.
Male	155 (47.7)	113 (45.9)	42 (53.2)	1.3 (0.8-2.2)

Table 3.12 (Continued)

Variables	n (%)	Risk perception		cOR
		<22 scores n (%), (n=246)	≥22 Scores n (%), (n=79)	(95% CI)
2.Age[b] (years),				
mean ±SD	56±15.3			
≥60	125 (38.5)	105 (42.7)	20 (25.3)	Ref.
46-59	141 (43.4)	100 (40.7)	41 (51.9)	2.2 (1.2-4.0)*
≤45	59 (18.2)	41 (16.7)	18 (22.8)	2.2 (1.1-4.7)*
3.Income (baht/month)[b]				
mean±SD	4154.2±5974.9			
≤1,000	126 (38.8)	111 (45.1)	15 (19.0)	Ref.
1,001-4,000	95 (29.2)	65 (26.4)	30 (38.0)	3.4(1.7-6.8)**
≥4,001	104 (32.0)	70 (28.5)	34 (43.0)	3.6(1.8-7.1)**
4.Education[a]				
≤Primary school	240 (73.8)	182 (74.0)	58 (73.4)	Ref.
>Primary school	85 (26.2)	64 (26.0)	21 (26.6)	1.0 (0.6-1.8)
5.Marital Status[a]				
Single	50 (15.4)	38 (15.4)	12 (15.2)	Ref.
Married	275 (84.6)	208 (84.6)	67 (84.8)	1.0 (0.5-2.1)
6.Occupation[b]				
Light labor	82 (25.2)	72 (29.3)	10 (12.7)	Ref.
Moderate labor	150 (46.2)	107 (43.5)	43 (54.4)	2.9 (1.4-6.1)**
Heavy labor	93 (28.6)	67 (27.2)	26 (32.9)	2.8 (1.3-6.2)*
7.Smoker[a]				
No	264 (81.2)	211 (85.8)	53 (67.1)	Ref.
Yes	61 (18.8)	35 (14.2)	26 (32.9)	3.0 (1.6-5.3)**
8.Alcohol user[a]				
No	238 (73.2)	185 (75.2)	53 (67.1)	Ref.
Yes	87 (26.8)	61 (24.8)	26 (32.9)	1.5 (0.9-2.6)

Table 3.12 (Continued)

Variables	n (%)	Risk perception		cOR
		<22 scores n (%), (n=246)	≥22 Scores n (%), (n=79)	(95% CI)
9.Respiratory symptoms (number)[b]				
None	210 (64.6)	171 (69.5)	39 (49.4)	Ref.
1-2	34 (10.5)	26 (10.6)	8 (10.1)	1.4 (0.6-3.2)
≥3	81 (24.9)	49 (19.9)	32 (40.5)	2.9 (1.6-5.0)**
10.Distance (meters)[b], mean±SD	97.6±39.2	101.1±38.5	86.7±39.3	
>100	48 (14.8)	29 (11.8)	19 (24.0)	Ref.
51-100	109 (33.5)	79 (32.1)	30 (38.0)	1.8 (1.1-3.0)*
≤50	168 (51.7)	138 (56.1)	30 (38.0)	2.5 (1.3-4.9)**

*p<0.05; **p<0.01; Risk perception<22 score=a good risk perception, Risk perception ≥22 scores= a poor risk perception

3.5.4 Preventive behaviors of crystalline silica exposure in stone-mortar workers and people living around stone-mortar factories

Preventive behaviors of crystalline silica exposure in SMW were found that the most of good personal protective equipment (PPE) wearing while working behaviors were “you wear mask, when exposed air pollution from stone-mortar dust”43 (55.8%), and “you keep PPE in clean, when do not exposed to air pollution from stone-mortar dust” 36 (46.8%). The most of bad PPE wearing while working behaviors were “you hang cloths, when exposed air pollution from stone-mortar dust” 57 (74.0%).The most of good knowledge were “you have knowledge to self-prevention, when exposed air pollution from stone-mortar dust”31 (40.3%), and “you walk away, when exposed air pollution from stone-mortar dust” 30 (39.0%).The most of bad environmental management were “you take food at workplace of stone mortar area.”60 (77.9%), and “you drink water at workplace of stone-mortar area” 41 (53.2%) (Table 3.13).

Preventive behaviors of crystalline silica exposure in SMW were found that the most of good preventive behaviors of crystalline silica exposure were “you wear mask, when exposed air pollution from stone-mortar dust"27 (47.4%), "you keep PPE in clean, when do not exposed to air pollution from stone-mortar dust" 18 (31.6%) and "you wear PPE all times in working time, when exposed air pollution from stone-mortar dust" 17 (29.8%). The most of bad preventive behaviors of crystalline silica exposure were "you hang cloths, when exposed air pollution from stone-mortar dust" 34 (59.6%), "you take food at workplace of stone-mortar area" 33 (57.9%) and "you drink water at workplace of stone-mortar area" 17 (29.8) (Table 1 in appendix).

Preventive behaviors of crystalline silica exposure in people living around stone-mortar factories were found that the most of good PPE wearing while working behaviors were "you wear mask, when exposed air pollution from stone-mortar dust" 77 (23.7%), and "you keep PPE in clean, when do not exposed to air pollution from stone-mortar dust" 67 (20.6%). The most of bad PPE wearing while working behaviors were "you hang cloths, when exposed air pollution from stone-mortar dust" 231 (71.1%). The most of good knowledge were "you walk away, when exposed air pollution from stone-mortar dust" 117 (36.0%), and "you have knowledge to self-prevention, when exposed air pollution from stone-mortar dust" 67 (20.6%). The most of badenvironmental management were "you take food at workplace of stone-mortar area."282 (86.8%), and "you drink water at workplace of stone-mortar area" 270 (83.1%) (Table 3.13).

Preventive behaviors of crystalline silica exposure in people living around stone-mortar factories were found that the most of bad preventive behaviors of crystalline silica exposure were "you take food at workplace of stone-mortar area". 228 (70.2%), "you drink water at workplace of mortar stone area." 223 (68.6%) and "you hang cloths, when find air pollution from stone-mortar dust." 172 (52.9%) (Table 2 in appendix).

Table 3.13 Preventive behaviors of crystalline silica exposure in stone-mortar workers and people living around stone-mortar factories.

Behaviors	SMW (n=57)		People living around stone-mortar factories (n=325)	
	Never/ Sometimes	Often/ Always	Never/ Sometimes	Often/ Always
Wearing PPE when exposed air pollution				
1. You wear mask, when you exposed air pollution from stone-mortar dust.	34 (44.2)	43 (55.8)	248 (76.3)	77 (23.7)
2. You hang cloths, when you exposed air pollution from stone-mortar dust.	20 (26.0)	57 (74.0)	94 (28.9)	231 (71.1)
3. You wear PPE and follow-up procedures, when you exposed air pollution from stone-mortar dust.	45 (58.4)	32 (41.6)	264 (81.2)	61 (18.8)
4. You wear N95 mask, when you exposed air pollution from stone-mortar dust.	64 (83.1)	13 (16.9)	302 (92.9)	23 (7.1)
5. You wear PPE all times in working time, when you exposed air pollution from stone-mortar dust.	49 (63.6)	28 (36.4)	271 (83.4)	54 (16.6)
6. You keep PPE in clean, when you do not expose to air pollution from stone-mortar dust.	41 (53.2)	36 (46.8)	258 (79.4)	67 (20.6)

Table 3.13 (Continued)

Behaviors	SMW (n=57)		People living around stone-mortar factories (n=325)	
	Never/ Sometimes	Often/ Always	Never/ Sometimes	Often/ Always
Knowledge				
7. You walk away, when you exposed air pollution from stone-mortar dust.	47 (61.0)	30 (39.0)	208 (64.0)	117 (36.0)
8. You have complaint, when you exposed air pollution from stone-mortar dust.	77 (100)	0.0 (0.0)	315 (96.9)	10 (3.1)
9. You have knowledge to self-prevention, when you exposed air pollution from stone-mortar dust.	46 (59.7)	31 (40.3)	258 (79.4)	67 (20.6)
10. You get knowledge to self-prevention from outsource, when you exposed air pollution from stone-mortar dust.	68 (88.3)	9 (11.7)	273 (84.0)	52 (16.0)
Environmental management				
11. You drink water at workplace of stone-mortar area.	36 (46.8)	41 (53.2)	55 (16.9)	270 (83.1)
12. You take food at workplace of stone-mortar area.	17 (22.1)	60 (77.9)	43 (13.2)	282 (86.8)
13. You open window, when you exposed air pollution from stone-mortar dust.	62 (80.5)	15 (19.5)	259 (79.7)	66 (20.3)
14. You avoid road, when you exposed air pollution from stone-mortar dust.	60 (77.9)	17 (22.1)	235 (72.3)	90 (27.7)

3.6 Health related quality of life in stone-mortar workers and people living around stone-mortar factories

This study has shown that HRQOL in SMW and people living around stone-mortar factories consisted of 1) HRQOL in SMW and people living around stone-mortar factories, 2) factors associated with health related quality of life among SMW, and 3) factors associated with HRQOL among people living around stone-mortar factories as following:

3.6.1 Health related quality of life in stone-mortar workers and people living around stone-mortar factories

Scores on HRQOL of stone-mortar workers found that the average physical component summary (PCS) score was higher than those of the HRQOL of Thais' healthy national volunteer as follows: 81.7%, and 75.1% respectively. The average mental component summary (MCS) score was slightly higher than those of the HRQOL of Thais' healthy national volunteer as follows: 76.9%, and 76.7% respectively. Average of role limitations due to physical health and role limitations because of emotional problems were lower than those of the the HRQOL of Thais' healthy national volunteer.

Scores on HRQOL of people living around stone-mortar factories found that the average of PCS scores were higher than those of of Thais' healthy national volunteer as follows: 79.2%, and 75.1% respectively. The average of MCS scores were lower than those of Thais' healthy national volunteer as follows: 75.2%, and 76.7% respectively (Table 3.14).

Table 3.14 Mean±SD of health related quality of life score of stone-mortar workers and people living around stone-mortar factories

HRQOL domains	SMW (n=57)	People living around stone-mortar factories (n=380)	HRQOL Thais' volunteer [a]
PCS	81.7±13.1	79.2±17.2	75.1±20.6
Physical functioning (PF)	94.6±9.8	86.6±20.2	77.3±17.4

Table 3.14 (Continued)

HRQOL domains	SMW (n=57)	People living around stone-mortar factories (n=380)	HRQOL Thais' volunteer [a]
Role limitations due to physical health (RP)	75.0±36.3	79.6±35.3	82.2±28.6
Bodily pain (BP)	88.0±13.3	83.8±18.6	75.6±18.4
General health (GH)	69.4±16.9	66.8±19.1	65.1±18.1
MCS	76.9±13.2	75.2±12.8	76.7±19.1
Vitality (VT)	70.1±15.6	70.1±14.6	62.2±13.3
Social functioning (SF)	80.5±22.5	71.0±22.3	78.2±18.2
Role limitations because of emotional problems (RE)	78.4±36.5	84.6±33.1	80.4±31.9
Mental health (MH)	78.7±16.0	75.1±15.8	66.1±12.9

[a]Thais' healthy national volunteer of Lim et al. (2008) [139]

PCS=Physical component summary, MCS= Mental component summary

3.6.2 Factors associated with health related quality of life among stone-mortar workers

The PCS, MCS and overall HRQOL were not significantly different as regards sex, age, income, marital status, education, length of living, smoker, alcohol use, respiratory symptoms and underlying diseases in stone-mortar workers (Table 3.15).

Table 3.15 Factors associated with health related quality of life among stone-mortar workers

Associated factors	PCS	*p*-value	MCS	*p*-value	Overall (n=57)	*p*-value
1. Sex[a]						
Male	82.0±13.6	0.277	77.1±13.6	0.189	79.5±12.3	0.259
Female	79.5±8.0		75.0±8.0		77.3±7.1	
2. Age (years)[b]						
≤25	93.6±2.1	0.055	80.6±14.0	0.816	87.1±6.7	0.397
26-45	78.6±10.5		79.4±9.0		79.0±8.8	
46-64	81.3±14.8		75.0±15.3		78.2±13.9	
≥65	88.8±3.3		78.7±6.5		83.7±4.8	
3. Income (Baht/month)[b]						
≤1,000	-	0.504	-	0.410	-	0.723
1001-4000	81.7±8.1		79.9±12.1		80.8±8.7	
4001-8000	84.6±10.2		78.8±9.3		81.7±7.8	
≥8001	78.2±17.8		72.7±17.0		75.5±16.6	
4. Marital status[b]						
Single	86.8±9.3	0.626	82.5±124.	0.544	84.6±6.9	0.484
Married	81.2±13.7		76.3±13.4		78.7±12.5	
Divorce	80.3±8.4		75.5±13.2		77.9±9.2	
5. Education[b]						
Primary school	81.7±13.8	0.870	77.6±14.5	0.535	79.6±12.9	0.681
Secondary School	82.1±11.1		76.6±11.8		79.4±11.4	
Higher	80.9±10.2		73.5±9.4		77.2±7.2	

Table 3.15 (Continued)

Associated factors	PCS	*p*-value	MCS	*p*-value	Overall (n=57)	*p*-value
6. Length of living in this community (years)[b]						
≤ 20	86.4±12.7	0.327	79.7±11.2	0.982	83.0±9.9	0.812
21-40	80.2±11.0		77.8±8.9		79.0±9.0	
41-60	80.2±14.7		76.0±15.2		78.1±13.9	
>60	88.9±5.0		76.8±14.0		82.8±8.2	
7. Smoker[a]						
No	83.9±13.0	0.095	77.5±13.6	0.451	80.7±12.2	0.197
Yes	79.2±13.1		76.2±12.9		77.7±11.7	
8. Alcohol user[a]						
No	79.6±15.8	0.576	78.9±15.0	0.233	79.2±14.4	0.607
Yes	82.7±11.8		76.0±12.4		79.4±10.8	
9. Respiratory symptoms[a]						
No	82.4±13.8	0.560	76.0±12.7	0.487	79.2±11.7	0.798
Yes	81.1±12.6		77.8±13.9		79.5±12.4	
10. Underlying diseases [a]						
No	80.9±14.0	0.571	76.6±13.8	0.637	78.8±12.8	0.615
Yes	85.7±6.8		78.2±10.4		82.0±6.3	

[a]Presented in Mann-Whitney U test, [b]Kruskal-Wallis test; $*p<0.05$, $**p<0.01$

3.6.3 Factors associated with health related quality of life among people living around stone-mortar factories

There were significant differences between the associated factors such as age, income, marital status, education, occupation, period of living in this community, alcohol use, underlying diseases and PCS scores among people living around stone-mortar factories. In addition, there were significant differences between the associated factors such as income, education, respiratory symptoms, underlying diseases and MCS scores among people living around stone-mortar factories. The overall HRQOL was significantly different the associated factors such as age, income, education, occupation, respiratory symptoms, underlying diseases and the overall HRQOL among people living around stone-mortar factories. Moreover, the distance between residential home and stone-mortar factories of people living around stone-mortar factories were significantly different as regards PCS, MCS and overall HRQOL (Table 3.16).

Table 3.16 Association between demographics, health characteristics, residential distance and health related quality of life among people living around stone-mortar factories

Associated factors	PCS	*p*-value	MCS	*p*-value	Overall (n=380)	*p*-value
1. 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	
2. 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	
3. 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	
4. 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	
5. 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	

Table 3.16 (Continued)

Associated factors	PCS	*p*-value	MCS	*p*-value	Overall (n=380)	*p*-value
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/ 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	
7. 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	
8. 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	
9. 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	
10. 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	
11. Underlying diseases[b]						
No	81.4±16.0	0.000**	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	

Table 3.16 (Continued)

Associated factors	PCS	*p*-value	MCS	*p*-value	Overall (n=380)	*p*-value
10. 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	
11. Underlying diseases[b]						
No	81.4±16.0	0.000**	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	
12. 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	
13. 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

The distance of residential home was significantly negative associated with physical, mental and overall HRQOL after adjusting for age, respiratory symptoms and underlying diseases using the multivariable analysis. An increased distance of residential home was associated with increased physical HRQOL, mental HRQOL, and overall HRQOL among people living around stone-mortar factories (Table 3.17).

Table 3.17 Association of residential distance from stone-mortar factory with health related quality of life among people living around stone-mortar factories using multiple linear regression analysis

HRQOL (n=380)	B	SE	*p*-value
Physical component summary	-0.042	0.021	0.043*
Mental component summary	-0.032	0.016	0.047*
Overall HRQOL	-0.037	0.017	0.026*

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

3.7 Dose-response relationship between dust exposure and respiratory disorders and inflammatory biomarkers among stone-mortar workers

This study has shown that the dose-response relationship between dust exposure and respiratory disorders and inflammatory markers among stone-mortar workers consisted of 1) association of crystalline silica concentration with respiratory disorders, and 2) association of crystalline silica concentration with serum CC16 and HO-1 levels as following:

3.7.1 Association of crystalline silica concentration with respiratory disorders

In our study, an eight-hour TWA concentrations and ADD of PM_{10} and crystalline silica in two groups were not associated with respiratory symptoms. Moreover, age and duration of dust exposure in two groups were not associated with respiratory symptoms. Moreover, current smoker, and wearing a mask while working were not significantly different to associated with respiratory symptoms in two groups. (Table 3.18).

Table 3.18 The correlation between characteristics, silica concentrations and respiratory symptoms in stone-mortar workers and control groups

Asscociated factors	Respiratory symptoms	
	SMW (n=57)	Controls (n=20)
Age[a], years	0.113	0.010
Current smoker[b]	-0.252	-1.319
Duration of dust exposure[a], years	0.185	-
Wearing a mask while working[b]	-0.147	0.000
PM_{10} concentration[a]		
8-hr TWA, mg/m^3	-0.022	-0.060
ADD, mg/kg-day	0.170	-
Crystalline silica concentration[a]		
8-hr TWA, mg/m^3	-0.024	0.319
ADD, mg/kg-day	0.105	-

[a]Presented in Spearman's rank correlation test (r), [b]Mann-Whitney U test (z)

In our study, an eight-hour TWA concentrations and ADD of PM_{10} and crystalline silica in two groups were not significantly associated with the respiratory symptoms after adjusting for age, duration of exposure, cotton mask and N95 mask use while working and pack-year smoking history (Table 3.19).

Table 3.19 Association between PM_{10} and crystalline silica concentrations with respiratory symptoms among stone-mortar workers and controls by multiple linear regression analyses

Associated factors (n=77)	Respiratory symptoms	
	B	SE
PM_{10} concentration[a]		
8-hr TWA, mg/m^3	0.616	0.419
ADD, mg/kg-day	5.901	5.749

Table 3.19 (Continued)

Associated factors (n=77)	Respiratory symptoms	
	B	SE
Crystalline silica concentration[a]		
8-hr TWA, mg/m^3	3.338	1.807
ADD, mg/kg-day	42.369	29.417

Adjusted for age, duration of exposure, cotton and N95 mask used while working and pack-years smoking

In our study, an eight-hour TWA concentrations and ADD of PM_{10} and crystalline silica in SMW and control groups were not associated with FEV_1, FVC, FEV_1/FVC, FEV_1 %predicted, FVC %predicted, and FEV_1/FVC %predicted. However, dust exposure durations in stone-mortar workers were negatively associated with FEV_1, FVC and FEV_1/FVC. Wearing a mask while working in SMW was significantly different to FVC %predicted in SMW. Age in stone-mortar workers was negatively associated with all pulmonary function parameters, except predicted FEV_1/FVC % while age in control group was also negatively associated with all pulmonary function parameters, except FEV_1/FVC and predicted FEV_1/FVC % (Table 3.20).

Table 3.20 The correlation between characteristics, silica concentrations and pulmonary functions in stone-mortar workers and control groups

Asscociated factors	FEV_1 (L)		FVC (L)		FEV_1/FVC (%)		$FEV_{1\%}$Predicted		FVC%Predicted		FEV_1/FVC %Predicted	
	SMW	Controls	SMW	Controls	SMW	Controls	SMW	Controls	SMW	Controls	SMW	Controls
Age[a], years	-0.599**	-0.777**	-0.551**	-0.640**	-0.360**	-0.230	-0.362**	-0.777**	-0.367**	-0.640**	-0.126	-0.230
Current smoker[b]	-1.978*	-1.070	-1.930	-1.149	-0.080	-0.436	-0.418	-1.070	-0.828	-1.149	-1.335	-0.436
Duration of dust exposure[a], years	-0.322*	-	-0.268*	-	-0.311*	-	-0.212	-	-0.180	-	-0.159	-
Wearing a mask while working[b]	-1.264	-1.026	-1.350	-1.064	-1.726	-0.494	-1.617	-1.026	-1.994*	-1.064	-0.742	-0.494
PM_{10} concentration[a]												
8-hr TWA, mg/m^3	-0.058	0.069	-0.026	0.197	-0.176	-0.269	-0.116	0.069	-0.103	0.197	-0.121	-0.269
ADD, mg/kg-day	-.0213	-	-0.118	-	-0.370**	-	-0.181	-	-0.111	-	-0.269*	-
Crystalline silica concentration[a]												
8-hr TWA, mg/m^3	0.000	-0.431	0.011	-0.431	-0.080	0.007	-0.111	-0.438	-0.092	-0.431	-0.137	0.007
ADD, mg/kg-day	-0.084	-	-0.034	-	-0.196	-	-0.097	-	-0.042	-	-0.213	-

[a]Presented in Spearman's rank correlation test (r), [b]Mann-Whitney U test (z); *p<0.05; **p<0.001; SMW (n=57), Controls (n=20)

In our study, an eight-hour TWA concentrations of PM_{10} in two groups were associated with FEV_1, FVC, FEV_1/FVC, FEV_1 %predicted, FVC %predicted, and FEV_1/FVC %predicted and ADD of PM_{10} in two groups were associated with FEV_1, FVC, FEV_1/FVC, FEV_1 %predicted, FVC %predicted, and FEV_1/FVC %predicted after adjusting for age, duration of exposure, cotton mask and N95 mask use while working and pack-year smoking history

An eight-hour TWA concentrations of crystalline silica in two groups were associated with FEV_1, FVC, FEV_1/FVC, FEV_1 %predicted, FVC %predicted, and FEV_1/FVC %predicted and ADD of crystalline silica in two groups were associated with FEV_1, FVC, FEV_1/FVC, FEV_1 %predicted, FVC %predicted, and FEV_1/FVC %predicted after adjusting for age, duration of exposure, cotton mask and N95 mask use while working and pack-year smoking history (Table 3.21).

Table 3.21 Association between PM_{10} and crystalline silica concentrations with pulmonary function test results among stone-mortar workers and controls by multiple linear regression analyses

Associated factors (n=77)	FEV_1		FVC		FEV_1/FVC		FEV_1 (%predicted)		FVC (%predicted)		FEV_1/FVC (%predicted)	
	B	SE	B	SE	B	SE	B	SE	B	SE	B	SE
PM_{10} concentration												
8-hr TWA, mg/m^3	-0.759**	0.141	-0.708**	0.173	-11.503**	2.057	-27.982**	5.155	-20.049**	4.852	-14.105**	2.530
ADD, mg/kg-day	-9.147**	2.007	-8.855*	2.398	-150.952**	28.451	-335.774**	73.428	-242.539**	67.750	-187.677**	34.796
Crystalline silica concentration												
8-hr TWA, mg/m^3	-1.956**	0.692	-1.944*	0.805	-29.824**	10.156	-79.377**	24.994	-58.365*	22.485	-40.010**	12.332
ADD, mg/kg-day	-37.429**	10.896	-35.525**	12.824	-627.855**	156.560	-1430.997**	395.861	-998.032**	360.535	-817.115**	189.682

Adjusted for age, duration of exposure, cotton and N95 mask used while working and pack-years smoking; *$p<0.05$, **$p<0.01$

Average daily doses (ADD) of PM_{10} and crystalline silica concentrations were differentially associated with chest radiographs. In addition, age and duration of dust exposure were also significantly association with chest radiographs (Table 3.22).

Table 3.22 The correlation between characteristics, silica concentrations and chest radiographs in stone-mortar workers and control groups

Asscociated factors (n=77)	Chest radiographs
Age[a], years	-3.099**
Current smoker[b]	0.666
Duration of dust exposure[a], years	-3.311**
Wearing a mask while working[b]	0.063
PM_{10} concentration[a]	
8-hr TWA, mg/m^3	-0.985
ADD, mg/kg-day	-2.619**
Crystalline silica concentration[a]	
8-hr TWA, mg/m^3	-0.920
ADD, mg/kg-day	-2.434*

[a]Presented in Mann-Whitney U test (z), [b]Fisher's exact test; ***p*<0.001

In our study, an eight-hour TWA of PM_{10} and crystalline silica concentrations were not associated with chest radiographs and ADD of PM_{10} and crystalline silica concentrations were not associated with chest radiographs after adjusting for age, duration of exposure, cotton mask and N95 mask use while working and pack-year smoking history (Table 3.23).

Table 3.23 Association between PM_{10} and crystalline silica concentrations with chest radiographs among stone-mortar workers and controls by multiple binary logistic regression analysis

Associated factors (n=77)	Chest radiographs	
	B	SE
PM_{10} concentration[a]		
8-hr TWA, mg/m^3	1.273	0.843
ADD, mg/kg-day	14.479	9.421
Crystalline silica concentration[a]		
8-hr TWA, mg/m^3	3.226	4.336
ADD, mg/kg-day	51.616	50.158

Adjusted for age, duration of exposure, cotton and N95 mask used while working and pack-years smoking

3.7.2 Association of crystalline silica concentration with serum CC16 and HO-1 levels

In our study, an eight-hour TWA of PM_{10} and crystalline silica concentrations in stone-mortar workers and control groups were not associated with CC 16 and HO-1. Moreover, ADD of PM_{10} and crystalline silica concentrations were not associated with CC 16 and HO-1. However, wearing a mask while working was significantly different to HO-1 in stone-mortar workers (Table 3.24).

Table 3.24 The correlation between characteristics, crystalline silica concentrations with CC 16 and HO-1 in stone-mortar workers and control groups

Asscociated factors	CC 16		HO-1	
	SMW	Controls	SMW	Controls
Age[a], years	0.135	0.450*	-0.242	0.202
Current smoker[b]	-1.987	-1.228	-0.112	-1.942
Duration of dust exposure[a], years	0.129	-	-0.172	-

Table 3.24 (Continued)

Asscociated factors	CC 16		HO-1	
	SMW	Control	SMW	Control
Wearing a mask while working[b]	-1.279	-1.701	-2.749**	0.851
PM_{10} concentration[a]				
8-hr TWA, mg/m^3	-0.014	0.102	-0.022	0.152
ADD, mg/kg-day	0.206	-	-0.093	-
Crystalline silica concentration[a]				
8-hr TWA, mg/m^3	-0.040	0.380	0.208	0.287
ADD, mg/kg-day	0.163	-	0.158	-

[a]Presented in Spearman's rank correlation test (r), [b]Mann-Whitney U test (z); *p<0.05; **p<0.001; SMW (n=57), Controls (n=20)

In our study, an eight-hour TWA of PM_{10} concentration was negatively associated with serum CC16 levels after adjusting for age, cotton and N95 mask used while working and pack-years smoking history (Table 3.25).

Table 3.25 Association of crystalline silica concentration with serum CC16 and HO-1 levels among stone-mortar workers and controls by multiple regression analysis

Associated factors (N=77)	CC 16		HO-1	
	B	SE	B	SE
PM_{10} concentration[a]				
8-hr TWA, mg/m^3	-2.106*	.940	2.898	10.950
ADD, mg/kg-day	-23.198	12.481	18.958	143.924
Crystalline silica concentration				
8-hr TWA (mg/m^3)	-11.833**	3.982	71.940	46.772
ADD (mg/kg-day)	-120.141	60.633	572.184	698.181

Adjusted for age, cotton and N95 mask used while working and pack-years smoking

In our study, an eight-hour TWA of PM_{10} concentration were associated with FEV_1/FVC %predicted, and serum levels of CC16 and HO-1 and ADD of PM_{10} concentration were associated with respiratory symptoms, FEV_1/FVC, FEV_1/FVC %predicted, and serum levels of CC16 and HO-1. Moreover, PM_{10} concentrations was significantly different to chest radiographs in two groups.

An eight-hour TWA of crystalline silica concentration were associated with FEV_1/FVC %predicted, and serum levels of CC16 and HO-1 and ADD of crystalline silica concentration were associated with respiratory symptoms, FEV_1/FVC %predicted, and serum levels of CC16 and HO-1. Moreover, crystalline silica concentration was significantly different to chest radiographs in two groups (Table 3.26).

Table 3.26 Association of PM_{10} and crystalline silica concentration with respiratory symptoms, pulmonary function, chest radiographs, CC16 levels and HO-1 levels among stone-mortar workers and controls

Associated factors (N=77)	Respiratory symptoms[a]	Pulmonary function[a]						Chest radiographs[b]	CC16[a]	HO-1[a]
		FEV_1	FVC	FEV_1/FVC	FEV_1 (%predicted)	FVC (%predicted)	FEV_1/FVC (%predicted)			
PM_{10} concentration[a]										
8-hr TWA, mg/m^3	0.175	0.026	0.077	-0.205	-0.072	0.009	-0.303**	-0.985	-0.466**	0.319**
ADD, mg/kg-day	0.308**	-0.069	0.012	-0.284*	-0.116	-0.010	-0.359**	-2.619**	-0.400**	0.284*
Crystalline silica concentration										
8-hr TWA (mg/m^3)	0.194	0.012	0.039	-0.127	-0.125	-0.049	-0.284*	-0.920	-0.474**	0.467**
ADD (mg/kg-day)	0.276*	0.004	0.057	-0.187	-0.071	0.026	-0.332**	-2.434*	-0.418**	0.434**

[a]Presented in Spearman's rank correlation test (r); [b]Mann-Whitney U test (z); $p<0.05$, $^{**}p<0.01$

An eight-hour TWA of PM_{10} and crystalline silica concentration were associated with serum CC16 levels using multiple regression analysis after adjusting for age, current smoker, wearing a mask while working. Moreover, our studies found that an eight-hour TWA and ADD of PM_{10} and crystalline silica concentration were not associated with serum CC16 and HO-1 levels after adjusting for age, current smoker, wearing a mask while working, pulmonary function. (data not shown) (Table 3.27).

Table 3.27 Association of silica concentration with serum CC16 and HO-1 levels among stone-mortar workers and controls by multiple regression analysis

Associated factors	CC 16		HO-1	
(N=77)	B	SE	B	SE
PM_{10} concentration[a]				
8-hr TWA, mg/m^3	-2.047*	0.940	-0.068	10.644
ADD, mg/kg-day	-21.541	12.688	-15.362	141.941
Crystalline silica concentration				
8-hr TWA (mg/m^3)	-11.736**	3.977	56.443	45.713
ADD (mg/kg-day)	-110.412	61.757	313.676	691.413

Adjusted for age, current smoker, wearing a mask while working; *p<0.05, **p<0.01

CHAPTER 4

DISCUSSIONS AND SUGGESTIONS

This study had two phases of the study processes which first phases was a retrospective cohort to identify the dose-response association of respirable dust exposure with respiratory disorders and biomarkers among 57 stone-mortar workers (SMW) and 20 controls with aged over 18 years and lived at study areas for at least 1 year, and second phases was a cross-sectional study to assess 57 stone-mortar workers, 325 people living around stone-mortar factories for risk perception, and 380 people living around stone-mortar factories for health related quality of life (HRQOL) with aged over 18 years and lived at study areas for at least 1 year. Data were collected from January to March 2017.

The instruments and measures consisted of particulate matter less than ten micrometers in diameter (PM_{10}) and crystalline silica exposure, respiratory symptoms with the American Thoracic Society Division of Lung Disease questionnaire (ATS-DLD-78A), clara cell 16 (CC16) and heme oxygenase-1 (HO-1) detection with using enzyme-linked immunosorbent assays (ELISA) kits, pulmonary function test with spirometer, chest radiography following International Labour Organizatio (ILO) guidelines and global positioning system (GPS) tool and questionnaires asked for interviewt risk perception with a questionnaire for original use in France which was translated into the Thai language with content validity and reliability of risk perception questionnaire, preventive behavior of crystalline silica exposure with content validity and reliability, HRQOL with 36 item short form survey (SF-36). Multiple linear regression analysis was used to examine the association of PM_{10} and crystalline silica with respiratory disorders, and serum level of CC16 and HO-1. Binary logistic regression analysis and multiple linear regression analysis were used to examine the association of associated factors with risk perception and HRQOL.

4.1 Conclusions

Occupational exposure to crystalline silica led to reduces serum CC16 and increased serum HO-1 among SMW. The concentration of crystalline silica was significantly associated with serum CC16 levels after adjustment for age, current smoker, dust exposure duration, wearing a mask while working, co-morbidity and pulmonary functions. Therefore, our data provides novel evidence that serum CC16 should be useful as a biomarker of effect from crystalline silica exposure and to predict the health risk of stone-mortar workers. Further studies on the detailed molecular mechanisms for short- and long-term exposure to crystalline silica resulting in the reduction of serum CC16 levels among SMW are warranted.

In addition, all stone-mortar factories produce inhalable dust pollutants, especially PM_{10} containing crystalline silica, which affects respiratory symptoms and a poorer risk perception of those residents living around stone-mortar factories. Moreover, our findings have shown that SMW were exposed to excessive crystalline silica level but PM_{10} level did not exceed the standard level. Therefore, this exposure was associated with respiratory disorders and pulmonary function impairment among SMW and people living around stone-mortar factories.

However, crystalline silica exposure is a preventable health hazard. SMW in the study area should be regulated to use appropriate personal protective equipment (PPE), Especially N95 masks are widely used as a self-preventive measure for high health risk areas and should be screened periodically for respiratory disorders, pulmonary function impairment and silicosis. Meanwhile, knowledge and advice should be provided to SMW, particularly respiratory disorders who are more likely to receive adverse effects directly from air pollution for them to minimize the potential harm from continued exposure to air pollution from stone-mortar factories. Further studies are needed to determine if strict enforcement of using PPE with result in reduction of respiratory disorders and risk of silicosis.

In addition, those residential home living around stone-mortar factories should consider appropriate PPE. Meanwhile, knowledge and advice should be provided to those residential home living near stone-mortar factories, particularly lung disease patients, and elder with respiratory symptoms who are more likely to receive adverse effects directly from air pollution for them to minimize the potential harm from continued exposure to air pollution from stone-mortar factories.

Finally, developing industries provide socioeconomic advantages to workers and communities living near air pollution sources, these advantages affect health risks and HRQOL when there is a lack of control measures as regards air polluting sources. Our studies have shown that SMW and people living around stone-mortar factories had high respiratory disorders. It was also shown that SMW and people living around stone-mortar factories will lead to a decrease in HRQOL. Therefore, the local policy makers should aim to be providing in place practices and procedures to reduce household air pollution from stone-mortar factories to improve HRQOL. Moreover, these findings indicate the importance of the intervention and surveillance measures, especially for SMW and people living around stone-mortar factories with respiratory disorders, to reduce the risks of air pollution exposure and lead to better health.

4.2 Discussions

Our findings have the importance to discuss as follow:

1) This study showed high exposure concentration of PM_{10} and crystalline silica in SMW. PM_{10} concentration in SMW did not exceed the recommended level while crystalline silica concentration in SMW was exceeded the exposure limit proposed by the American Conference of Governmental Industrial Hygienists (ACGIH) [127]. These results are consistent with the findings from previous research of Nambunmee et al. which found a high level of atmospheric crystalline silica dust in the stone mortar and pestle production industry among Thai stone workers in 2014 [30]. According to Chanvirat et al. reported the stone-carving workers in 2018 were exposed to high concentrations of respirable crystalline silica and this level exceeded the Occupational Safety and Health Administration (OSHA) and the ACGIH standard limits [127,140]. Our study also found that the risk characterization of PM_{10} and crystalline silica in stone-mortar workers, which was expressed as health quotient (HQ), were considered unacceptable and possibly affected humans according Ministry of Public Health and the United States Environmental Protection Agency (US EPA) guidelines [123,124]. In our study, the studied stone cutters and stone grinders had greater the levels of PM_{10} and crystalline silica than control, but PM_{10} level did not exceed the standard level of

ACGIH guidelines but crystalline silica exposure levels did exceed the standard level of OSHA (2018) [127]. This finding is similar to previous studies which were conducted among Thai stone workers of Nambunmee et al. (2014); Chaiear et al. (2017); Chanvirat et al. (2018) and in Iranian stone workers of Mohammadi et al. (2017) [31,140-142].

Moreover, our studies found that the crystalline silica concentration in all factories were exceeded the exposure limit proposed by the National Institute for Occupational Safety and Health (NIOSH) and ACGIH guidelines for each stone-mortar process, such as stone cutting and grinding, in home stone-mortar factories. However, stone-mortar factories are a household products industry and mostly informal sector workers which these areas were an open system causing ventilation problems and lack appropriate the concentration controls of air pollution. These results are consistent with the findings from previous research of Bhagia (2012) indicating high concentrations of crystalline silica in stone-mortar factories when compared with other occupational groups [143]. Moreover, these results are consistent with the findings from previous research of Kuo et al. (2018) that indicating the association between the high levels of respirable dust and crystalline silica concentrations [144].

2) Our studies were collected PM_{10} concentration using a personal sampling pump in the vests of the workers' breathing zone for an 8-hour work day period. These measurements were representing individual exposure of PM_{10} and crystalline silica in these areas as following the National Institute for Occupational Safety and Health (NIOSH) method 0600 guides for respirable particulates not otherwise regulated as following NIOSH (1998) and the NIOSH method 7601 as following NIOSH 2003 with a visible absorption spectrophotometer [125,126]. Moreover, our studies found that some respiratory symptoms such as coughing, phlegm and coughing with phlegm were upper respiratory system. However, $PM_{2.5}$ may be measured in the further study because some respiratory symptoms such as wheezing, difficulty in breathing and chest pain were lower respiratory system including decreased pulmonary function and two biomarkers due to $PM_{2.5}$ can penetrate deeply into the lung.

3) Our studies found that the respiratory symptoms such as coughing, phlegm, coughing with phlegm, nose irritation, stuffy nose, chest pain, wheezing, and difficulty in breathing due to stone-mortar production has been producing PM_{10} containing crystalline silica since the industry began and these particles can enter the nose, throat, and lungs. Workers exposed to PM_{10} and crystalline silica in the workplace experienced irritation in the respiratory tract which causes respiratory symptoms. These findings

were also consistent with previous studies of Sivacoumar et al. (2001); Sun et al. (2013); Isara et al. (2016) that the high concentration of PM_{10} containing crystalline silica, in both the working area and the living environment, is associated with human health problems such as respiratory disorders [145-147]. Besides, we found that approximately 55% of stone cutters and 43% of stone grinders had respiratory symptoms such as coughing with phlegm, coughing, and coughing with wheeze and phlegm. These findings were also consistent with previous studies of Rafeemanesh et al. (2014); Yingratanasuk et al. (2014); Silanun et al. (2017) [19,33,148]. In addition, people living around stone-mortar factories had respiratory symptoms consisting of coughing, phlegm, nose irritation, stuffy nose, and coughing with phlegm. This finding is consistent with current literature of of Garshick et al. (2003) and Doiron et al. (2017) that indicates an association between respiratory symptoms and living near air pollution sources [149,150].

4) Our studies have shown that crystalline silica exposure was associated with reduced pulmonary function such as forced expiratory volume in one second ($FEV_{1)}$, forced vital capacity (FVC) and force expiratory volume in one secon/ forced vital capacity (FEV_1/FVC) levels similar to prior research studies of Hertzberg et al. (2002); Mohammadi et al. (2017); Lamichhane et al. (2018) [142,151,152]. Thus, SMW should be investigated with pulmonary function testing. Moreover, our studies have shown that stone cutters and grinders had obstructive lung disease and others had restrictive lung disease. This finding was similar to previous studies of Aghilinejad et al. (*2*012) from Iran found that the most common abnormality of pulmonary function among SMW were obstructive lung disease followed by restrictive lung disease [153]. Among workers who were chronically exposed to crystalline silica, the particles interacted with lung tissue to promote the persistent inflammation through the production of oxidant substance in the alveolar space. The reactive oxygen species (ROS), major oxidant substance, was produced by macrophages attempting to breakdown the silica [154]. Hence, the exposure with the high concentration of crystalline silica probably damaged the lining of the lung air sacs and decreased pulmonary functional performance [40,41]. However, our study found that all pulmonary function parameters in SMW were normal and not significantly different from the control group, except the percent of predicted FEV_1/FVC. In addition, we did not observe the relationship between crystalline silica concentration and all pulmonary function parameters.

5) In our study, there were significantly a higher number of abnormal chest radiographs in stone cutters and stone grinders than controls. Fourteen percent of stone cutters and grinders had abnormal chest radiographs, 3 had findings consistent with silicosis. Therefore, these results are in agreement with the findings of other research studies of Rafeemanesh et al. (2014) reported 16.4% of studied stone grinders had abnormal chest radiographs in Iran [19]. In our study found that the percentage of study subjects with abnormal chest radiographs was greater than a previous study from Thailand (8.9%) of Silanun (2014) [155]. It is possible that SMW might be lower risk to crystalline silica exposure in the workplace area. This reason was supported by the type of stone factories in this study household being industry and open ventilation system. Besides, we found that approximately 50% of workers in the exposure group wearing a mask while working which might have helped to reduce the exposure. Despite the lower risk of crystalline silica exposure in SMW, we found three abnormal chest radiograph findings diagnosed as silicosis. Likewise, previous studies reported the prevalence of silicosis in Thai stone workers of Nambunmee et al. (2014); Silanun, (2014); Silanun et al. (2017) [32,33,156].

6) Our studies found that the serum CC16 level in SMW was significantly lower than those in control group. These findings were also consistent with previous studies of Bernard et al. (1994); Broeckaert et al. (2000); Wang et al. (2007) and Xiao et al. (2013) which found the reduction of serum CC16 in silica-exposed workers without respiratory symptoms, abnormal chest radiographs or pulmonary function tests [38,87,157,158]. Moreover, the serum CC16 was generally secreted into the respiratory tract and diffused across the bronchoalveolar-blood barrier into the plasma [159]. Hence, it could be suggested that the reduction of serum CC16 secretion into respiratory tract was possibly caused from crystalline silica-induced lung injury as describe elsewhere [160]. Beside the direct cell injury, the clara cells were damaged from the cytotoxin, which was released from silica-engulfed alveolar macrophages [38]. The possible mechanism in the reduction of serum CC16 was not only the clara cell injury but also the loss of permeability of the alveoli/blood capillary barrier. Generally, the CC16 is diffused to blood circulation through alveoli/blood capillary barrier under the pressure in a healthy population [87]. For this reason, it probably suggested that the alteration of serum CC16 in the silica-exposed group may be influenced by the disruption of the alveoli barrier.

On the contrary, there was a significantly higher level of serum HO-1 in SMW compared with those in control group. This finding is similar to previous studies of

Nagatomo et al. (2006); Sato et al. (2006); Nambunmee et al. (2014) [31,40,161]. Moreover, prior inflammatory induction, the hydroxyl radical, one of ROS, was produced by the silica particles. Subsequently, the antioxidant enzyme such as HO-1 was predominately released to respond to the toxicity of silica. Moreover, an eight-hour TWA of PM_{10} concentration was associated with serum CC16 levels using multiple regression analysis after adjusting for age, current smoker, wearing a mask while working. However, our studies found that an eight-hour TWA and ADD of PM_{10} and crystalline silica concentration were not associated with serum HO-1 levels after adjusting for age, current smoker, wearing a mask while working, pulmonary function. It is possible that the increase of HO-1 might result from co-morbidities such as diabetes, hypertension, chronic obstructive pulmonary disease (COPD), asthma, and cystic fibrosis including decreased pulmonary function [162-164]. From this reason, the finding of no association between crystalline silica and HO-1 was assumed in the study since the worker was probably exposed to a low level of crystalline silica due to these findings were also consistent with previous study of Nambunmee et al. (2014) which found the relationship of silica concentration and serum HO-1 levels between the low and high exposure group found significant relationships between silica level and serum HO-1 in the high silica exposure group only (silica concentration of 15.50 mg/m^3) [156].

Silicosis is an occupational respiratory disease. Practically, the measurement of silica in workplace is also necessary to control the incidence of silicosis [165-167]. The diagnosis of silicosis, which is based on clinical history and radiological findings, has been done. Unfortunately, pulmonary function is not specific to silicosis and lung lesions indentified by chest radiograph is obviously found in late stages. Furthermore, an effective method for early diagnosis remained currently unavailable [35,37,40,168].

7) Our studies found that those SMW had risk perception and preventive behavior at high level on respiratory tract protection. Respiratory tract problems were common among them. Risk perception had low level in smoker and respiratory tract disease. There were smoking and respiratory tract disease should concern in SMW, especially, are known to affect risk perception. Most importanttly, the wearing N95 mask while working all times at low level in SMW and people living around stone-mortar factories were 16.9% and 7.1% respectively due to N95 mask have the potential to prevent disease. In addition, several previous studies of Omanga et al. (2014)

reported that demographic factors were associated with air quality perception (AQP) variables and Chakraborty et al. (2017) found other contextual and socio-demographic factors that have influence in air pollution health risk perception [49,169]. In addition, Sivacoumar et al. (2001) and Isara et al. (2016) found inhalable particulate matter has associated with human impacts such as respiratory symptoms and pulmonary function in the work place of stone [145,147]. In Thailand, Janmaimool et al. (2014) found that high-risk community of environmental contamination also was significantly related to the degree of risk perception [170]. These findings suggest that SMW should increasing knowledge to self-prevention behavior in crystalline silica dust exposure and hazardous conditions. Smoker and people with respiratory tract disease should increasing health risk perception and preventive behavior. Therefore, these have the potential to provide education and training for the prevention of occupational lung disease.

Our studies have shown that the demographic characteristics and factors can affect a poor risk perception including age (young had poorer risk perception than older), income (low income had poorer risk perception than high income), occupation (moderate and heavy labors had poorer risk perception than light labor), smoking (smokers had poorer risk perception than non-smoker) and number of respiratory symptoms (increased the number of respiratory symptoms had poorer risk perception). In addition, there were found that low distance from home to stone-mortar factories was associated with a poor risk perception. Moreover, our study found that the demographic characteristics and factors associated with risk perception. Thus, these results are in agreement with the findings of other research studies of Egondi et al. (2013); Omanga et al. (2014); Guo et al. (2016) found that those characteristics have a bearing also on risk perception in order to the context and personal traits can influence a person's perception of health risks from air pollution [44,45,49].

Most importantly, our study found that an increased number of respiratory symptoms was associated with a poor risk perception. Especially, respiratory symptoms such as nose irritation, chest pain, and stuffy nose had associated with a poor risk perception. These results are in agreement with the findings of other research study of Brender et al. (2011) found that those residential home living close to home stone-mortar factories had more respiratory symptoms than those living far from home stone-mortar factories [171]. In addition, these results have shown that the health risk perceived levels of air pollution significantly influences respiratory symptoms that these results are consistent with the findings from previous study of Orru et al. (2018) [172].

Furthermore, our study has shown found that increasing distance from home to stone-mortar factories was associated with a good risk perception. Thus, this study showed that those residents living near home stone-mortar factories had a poorer risk perception than those living far from the pollution sources. these results are consistent with the findings from previous study of Egondi et al. (2013); Omanga et al. (2014); Pattinson et al. (2015); Li et al. (2016) found that people living close to the air pollution sources have a higher level of risk perception than those living in other conditions, and that the residents in the vinicity of air pollution sources have greater awareness about health risks from the familiar environmental hazards [44,49,173,174]. These results are in agreement with the findings of other research study of Janmaimool et al. (2014) found that the environmental pollution exposure risk was significant positive association with health risks perception. Thai people in communities having high risk of exposure to environmental pollutants appeared to have a high degree of health risks perception [170].

8) Our studies found that the average physical component summary (PCS) score was higher than those of the HRQOL of Thais' healthy national volunteer and The average mental component summary (MCS) score was slightly higher than those of the HRQOL of Thais' healthy national volunteer. Average of role limitations due to physical health and role limitations because of emotional problems score were lower than those of the the HRQOL of Thais' healthy national volunteer. However, air quality is a key factor in people's well-being due to HRQOL is strongly affected by the health outcomes. Moreover, physical environment such as the role limitations due to physical health and emotional problems influence the individual's health in SMW, neighborhoods (e.g., environments that increase physical activity etc.) and working environment, which affect the HRQoL. Although development within the industry provides socioeconomic advantages for both workers and communities, along with these advantages are increased health risks affecting HRQOL for both workers and communities due to the increase in air pollution [175].

Moreover, Lim et al. (2008) and Wang et al. (2008) found that the generic SF-36 tool has been extensively used worldwide for assessing HRQOL among exposed workers and people living around the air polluting sources [139,176]. Our studies have shown that people living around household stone-mortar factories, especially the residents living around stone-mortar factories within distances of less than 100 meters often had respiratory symptoms. These results are consistent with the findings from previous research of Laurent et al. (2007); Wang et al. (2008); Krewski, (2009); D'Souza et al. (2013); Darçın, (2014) that these symptoms can lead to an increased risk of poorer health status, more psychosocial stressors, and a reduced HRQOL. Several studies reported that the association of the short- and long- term effects with air pollution exposure can be induced by demographic characteristics, socioeconomic change and HRQOL both directly exposed workers and the people living around stone factories [65,71,176-178].

Furthermore, primary factors such as demographics, socioeconomics, and geographical region have been identified as being related to HRQOL. All these were related with HRQOL of residential home of people living near air pollution sources. These findings were also consistent with previous studies of Wang et al. (2008) and D'Souza et al. (2013), especially those characteristics of subjects, medical history, and lifestyle habits identified in the HRQOL scores of people living around stone-mortar factories [65,176]. In addition, Krewski, (2009) found that if possible changes should be made to address primary factors, socio-economic, and geographical region for residential home of people living near areas with high concentration of air pollution lead to increases in life expectancy and D'Souza et al. (2013) found that residential home in communities located closer to high concentration of air pollution sources were most likely to have poorer physical health, mental health, and HRQOL than those living at greater distance from the air pollution sources [65,178]. Most importantly, Zullig et al. (2010) and D'Souza et al. (2013) found that residential home in communities can easily be exposed to the dispersing pollutants in ambient air pollution, for example people living near air pollution sources [52,65]. Thus, the concerned agencies need advice and support the information as regards self-preventive measures to protect themselves.

The residential home of people living near stone-mortar factories tended to have a significantly negative HRQOL using the multivariate analysis. This finding was also consistent with previous studies of Lee et al. (2006) and Balmes et al. (2009) have shown that the residential home living near a garbage dumping site was significantly negative associated with quality of life in the physical and environmental domains [179,180]. There are many possible confounding factors that could affect this association such as traffic noise, living near roads or other pollution sources, buildings or other obstructions which might be influencing factors in the decrease of air pollution concentrations that this finding was similar to previous studies of Roswall et al. (2015) and Yang et al. (2015) [181,182]. Wind direction has also been shown to affect quality of air pollution and needs to be taken into consideration that this finding was also similar to previous study of Guerra et al. (2006) [183].

4.3 Limitation of the study

The limitations of this study were the small sample size of crystalline silica exposure group but we conducted in all available SMW and people living around stone-mortar factories who were willing to participate. The working area is an open system causing an uncertainty in the concentrations of PM_{10} and crystalline silica.

4.4 Suggestions

This study was to suggest the implementation for SMW and people living around stone-mortar factories, health personal, the factories and the further study as following:

4.4.1 Suggestion for implementation

This study was to suggest the implementation for reduce the health risks; increase the risk perception, preventive behaviours, and HRQOL as following;

1) The PM_{10} monitoring in stone-mortar factories: The results showed that PM_{10} did not exceed the standard level of ACGIH but crystalline silica exceeds the standard level of ACGIH guidelines. Therefore, the PM_{10} monitoring should be conducted at yearly periods in stone-mortar factories and communities. In addition, $PM_{2.5}$ have to be monitored due to $PM_{2.5}$ can penetrate deeply into the lung.

2) The surveillance for respiratory symptoms: The results showed that respiratory symptoms consisted of coughing, phlegm, coughing with phlegm, and nose irritation in SMW and respiratory symptoms consisteds of coughing, phlegm, nose irritation, stuffy nose, and coughing with phlegm in people living around stone-mortar factories. Therefore, respiratory symptom questionnaires, especially chronic respiratory symptoms, should be used to conduct a survey for screening both SMW and people living around stone-mortar factories.

3) The pulmonary function identification: The results showed that an eight-hour TWA concentrations and ADD of PM_{10} and crystalline silica in two groups were associated with FEV_1, FVC, FEV_1/FVC, FEV_1 %predicted, FVC %predicted, and FEV_1/FVC %predicted after adjusting for age, duration of exposure, cotton mask and N95 mask use while working and pack-year smoking history. Therefore, pulmonary function test should be conducted at yearly periods in SMW for other lung disease surveillance such as obstructive lung disease, a restrictive lung disease, and a mixed obstructive/ restrictive lung disease.

4) The chest radiograph finding identification: The results showed that abnormal chest radiograph findings in SMW consisted of eight cases, which three cases were diagnosed with silicosis. Chest radiograph findings should be conducted at yearly periods in SMW for silicosis surveillance and interpreted chest radiograph finding results by physician following ILO guildline.

5) The biomarkers, clara cell protein 16 (CC16) and heme oxygenase-1 (HO-1) detection: The results showed that a decrease in serum CC16 was further lowered after crystalline silica exposure in order to it is concluded that there is a decreased anti-inflammatory capacity in the serum. An increase in serum HO-1 was further highered after crystalline silica exposure in order to HO-1 has antioxidative, antiapoptotic and anti-inflammatory activities. Therefore, SMW, especially chronic lung disease and high dose exposure, should be monitored CC16 and HO-1 for health surveillance and these biomarkers are benefit for the prediction and prognosis assessment of silicosis.

6) The risk perception about air pollution: The results showed that SMW had awareness of health risks of crystalline silica exposure at 33.3% (n=19). Respiratory symptoms had a poor risk perception more than non-respiratory symptoms. Moreover, our studies found that seventy-nine subjects (24.3%) were found to have a poor risk perception in people living around stone-mortar factories. Interestingly, those with distance from residential home to stone-mortar factories between 51 and 100 meters and lower than 50 meters had a poorer risk perception than those whose distance from residential home to stone-mortar factories more than 100 meters. Therefore, SMW and people living around stone-mortar factories should be informed and educated on health risk perception and appropriate PPE using from exposure to PM_{10} containing crystalline silica to improve health risk perception and leads to better health.

7) The preventive behavior for dust exposure: The results showed that SMW and people living around stone-mortar factories had low preventive behavior of crystalline silica exposure such as hang clothes when exposed air pollution, take food and drink water at workplace of stone-mortar area. Therefore, SMW and people living around stone-mortar factories should be informed and educated on health preventive behavior from exposure to PM_{10} containing crystalline silica to improve preventive behavior and leads to better health.

8) The HRQOL monitoring: The results showed that the overall HRQOL were not significantly different as regards sex, age, income, marital status, education, length of living, smoker, alcohol use, respiratory symptoms and underlying diseases in SMW. Moreover, the overall HRQOL was significantly different the associated factors such as age, income, education, occupation, respiratory symptoms, underlying diseases and the overall HRQOL among people living around stone-mortar factories. Moreover, the distance between residential home and stone-mortar factories of people living around stone-mortar factories were significantly different in the overall HRQOL. Therefore, SMW annd people living around stone-mortar factories should be informed and educated health risk from exposure to PM_{10} containing crystalline silica when entering stone-mortar factories for self preventive behavior and leads to increased HRQOL. In addition, SMW should be checked HRQOL, especially the average of role limitations due to physical health and role limitations because of emotional problems score, for surveillance.

4.4.2 Suggestion for the further study

Further studies on the detailed molecular mechanisms for short- and long-term exposure to crystalline silica resulting in the reduction of serum CC16 levels among SMW are warranted. In addition, the studies are needed to determine if strict enforcement of using PPE with result in reduction of respiratory disorders and risk of silicosis and monitor the concentrations of PM_{10} and crystalline silica and respiratory disorder with the seasonal analyses. Most importantly, it is necessary to study qualitative research and longitudinal research design for other measurement of crystalline silica, inflammatory biomarkers (CC16 and HO-1) and respiratory disorders among SMW and people living around the stone-mortar factories. In addition, the study directly assessing $PM_{2.5}$ due to $PM_{2.5}$ can penetrate deeply into the lung.

REFERENCES

1. Yatkin S1, Bayram A. Determination of major natural and anthropogenic source profiles for particulate matter and trace elements in Izmir, Turkey. Chemosphere. 2008;71(4):685-96.
2. Ghorani-Azam A, Riahi-Zanjani B, Balali-Mood M. Effects of air pollution on human health and practical measures for prevention in Iran. J Res Med Sci. 2016;21:65.
3. Bauleo L, Bucci S, Antonucci C, Sozzi R, Davoli M, Forastiere F, et al. Long-term exposure to air pollutants from multiple sources and mortality in an industrial area: a cohort study. Occup Environ Med. 2019;76(1):48-57.
4. Liao X, Tu H, Maddock JE, Fan S, Lan G, Wu Y, et al. Residents' perception of air quality, pollution sources, and air pollution control in Nanchang, China. Atmos Pollut Res. 2015;6(5):835-41.
5. Healy CB, Coggins MA, Van Tongeren M, MacCalman L, McGowan P. Determinants of respirable crystalline silica exposure among stoneworkers involved in stone restoration work. Ann Occup Hyg. 2013;58(1):6-18.
6. Scarselli A, Binazzi A, Forastiere F, Cavariani F, Marinaccio A. Industry and job-specific mortality after occupational exposure to silica dust. Occup Med (Lond). 2011;61(6):422-9.
7. Leung CC, Yu IT, Chen W. Silicosis. Lancet. 2012;379(9830):2008-18.
8. Fanning EW, Froines JR, Utell MJ, Lippmann M, Oberdörster G, Frampton M, et al. Particulate matter (PM) research centers (1999-2005) and the role of interdisciplinary center-based research. Environ Health Perspect. 2009;117(2):167-74.
9. Masri S, Kang C-M, Koutrakis PJJotA, Association WM. Composition and sources of fine and coarse particles collected during 2002–2010 in Boston, MA. J Air Waste Manag Assoc. 2015;65(3):287-97.
10. IARC Working Group on the Evaluation of Carcinogenic Risks to Humans. Arsenic, metals, fibres, and dusts. IARC Monogr Eval Carcinog Risks Hum. 2012;100(Pt C):11-465.

11. Vacek PM, Verma DK, Graham WG, Callas PW, Gibbs GW. Mortality in Vermont granite workers and its association with silica exposure. Occup Environ Med. 2011;68(5):312-8.
12. Lee W, Ahn Y-S, Lee S, Song BM, Hong S, Yoon J-H. Occupational exposure to crystalline silica and gastric cancer: a systematic review and meta-analysis. Occup Environ Med. 2016;73(11):794-801.
13. World Health Organization (WHO). Task force 4: elimination of silicosis. [Cited 2016 May 9]. Available from: http://www.who.int/occupational_health/topics/silicosis/en/.
14. Hiraiwa K, van Eeden SF. Contribution of lung macrophages to the inflammatory responses induced by exposure to air pollutants. Mediators Inflamm. 2013;619523.
15. Sato T, Shimosato T, Klinman DM. Silicosis and lung cancer: current perspectives. Lung Cancer (Auckl). 2018;9:91-101.
16. Pattamak C. Seasonal variation and FEV_1/FVC among grind-stone workers in Srakrew Province, 2003. [Cited 2016 May 9]. Available from: http://klb.ddc.moph. go.th/dataentry/research/form/200.
17. Ministry of Labour. Diagnostic criteria of occupational diseases commemorative edition on the auspicious occasion of His Majesty the King's 80^{th} Birthday anniversary 5 December 2007, 2007. [Cited 2016 May 9]. Available from: https://www.sso.go.th/wpr/assets/upload/files_storage/sso_th/fed9ac2c9e46ad81b203e64b8a6a940c.pdf.
18. Yadav S, Anand P, Singh H. Awareness and practices about silicosis among the sandstone quarry workers in desert ecology of jodhpur, rajasthan, India. J Hum Ecol. 2011;33(3):191.
19. Rafeemanesh E, Majdi MR, Ehteshamfar SM, Fahoul MJ, Sadeghian Z. Respiratory diseases in agate grinding workers in Iran. Int J Occup Environ Med. 2014;5(3):130-6.
20. Nkosi V, Wichmann J, Voyi K. Chronic respiratory disease among the elderly in South Africa: any association with proximity to mine dumps?. Environ Health. 2015;14:33.

21. Das B. Assessment of respiratory symptoms and lung function values among the brick field workers of West Bengal, India. Arch Environ Occup Health. 20163;71(4):222-30.
22. Patto P, Loosereewanich P, Chantanakul S, Chansatitporn N. Pulmonary function abnormality from silica dust exposure among automotive part foundry workers. International Graduate Research Conference 2014, Chiang Mai University. 2014.
23. Meijer E, Kromhout H, Heederik D. Respiratory effects of exposure to low levels of concrete dust containing crystalline silica. Am J Ind Med. 2001;40(2):133-40.
24. Kakooei H, Gholami A, Ghasemkhani M, Hosseini M, Panahi D, Pouryaghoub G. Dust exposure and respiratory health effects in cement production. Acta Med Iran. 2012;50(2):122-6.
25. Danphaiboon A, Liewsaree W, Khantipongse J, Chaisuwan C, Khacha-ananda S, Singkaew J, et al. Blood hemeoxygenase-1 (HO-1) levels in stone mill workers who were exposed to silica in Upper North Thailand. Disease Control Journal. 2012;38(1):8-14.
26. Bang KM, Mazurek JM, Wood JM, White GE, Hendricks SA, Weston A. Silicosis mortality trends and new exposures to respirable crystalline silica - United States, 2001-2010. MMWR Morb Mortal Wkly Rep. 2015;64(5):117-20.
27. Tse LA, Dai J, Chen M, Liu Y, Zhang H, Wong TW, et al. Prediction models and risk assessment for silicosis using a retrospective cohort study among workers exposed to silica in China. Sci Rep. 2015;5:11059.
28. Aungkasuvapala N, Juengprasert W, Obhasi N. Silicosis and pulmonary tuberculosis in stone-grinding factories in Saraburi, Thailand. J Med Assoc Thai. 1995;78(12):662-9.
29. Khaophuthai S. Occupational and work-related diseases, 2009. [Cited 2016 May 9]. Available from: https://www.hiso.or.th /hiso/tonkit/tonkits17.php.
30. Nambunmee K, Danphaiboon A, Khantipongse J. Increased serum heme oxygenase-1 in silicosis-suspected subjects from limestone crusher factories. J Health Res. 2014;28(1).

31. Nambunmee K, Danphaiboon A, Khantipongse J. Serum heme oxygenase-1 level in silicosis patients and stone mortar and pestle production workers. Occup Environ Med. 2014;71(Suppl 1):A50-A.
32. Silanun K. Development of a disease surveillance system for silicosis and respiratory disorders in stone carving workers in Thailand. Occupational and environmental medicine. 2014;71(Suppl 1):A117-A.
33. Silanun K, Chaiear N, Rechaipichitkul W. Prevalence of silicosis in stone carving workers being exposed to inorganic dust at Sikhiu District Nakhonratchasima Province, Thailand; preliminary results. J Med Assoc Thai. 2017;100(5):598.
34. Pandey JK, Agarwal D. Biomarkers: A potential prognostic tool for silicosis. Indian J Occup Environ Med. 2012;16(3):101-7.
35. Fernandez Alvarez R, Martinez Gonzalez C, Quero Martinez A, Blanco Perez JJ, Carazo Fernandez L, Prieto Fernandez A. Guidelines for the diagnosis and monitoring of silicosis. Arch Bronconeumol. 2015;51(2):86-93.
36. Stacey P, Thorpe A, Roberts P, Butler O. Determination of respirable-sized crystalline silica in different ambient environments in the United Kingdom with a mobile high flow rate sampler utilising porous foams to achieve the required particle size selection. Atmos Env. 2018;182:51-7.
37. Rokicki W, Rokicki M, Wojtacha J, Dżeljijli A. The role and importance of club cells (Clara cells) in the pathogenesis of some respiratory diseases. Kardiochir Torakochirurgia Pol. 2016;13(1):26-30.
38. Bernard AM, Gonzalez-Lorenzo JM, Siles E, Trujillano G, Lauwerys R. Early decrease of serum Clara cell protein in silica-exposed workers. Eur Respir J. 1994;7(11):1932-7.
39. Broeckaert F, Bernard A. Clara cell secretory protein (CC16): characteristics and perspectives as lung peripheral biomarker. Clin Exp Allergy. 2000;30(4):469-75.
40. Sato T, Takeno M, Honma K, Yamauchi H, Saito Y, Sasaki T, et al. Heme oxygenase-1, a potential biomarker of chronic silicosis, attenuates silica-induced lung injury. Am J Respir Crit Care Med. 2006;174(8):906-14.

41. Provost EB, Chaumont A, Kicinski M, Cox B, Fierens F, Bernard A, et al. Serum levels of club cell secretory protein (Clara) and short- and long-term exposure to particulate air pollution in adolescents. Environ Int. 2014;68:66-70.
42. Sato T, Saito Y, Inoue S, Shimosato T, Takagi S, Kaneko T, et al. Serum heme oxygenase-1 as a marker of lung function decline in patients with chronic silicosis. J Occup Environ Med. 2012;54(12):1461-6.
43. Haas EJ, Willmer D, Cecala AB. Formative research to reduce mine worker respirable silica dust exposure: a feasibility study to integrate technology into behavioral interventions. Pilot Feasibility Stud. 2016;2(1):6.
44. Egondi T, Kyobutungi C, Ng N, Muindi K, Oti S, Vijver Svd, et al. Community perceptions of air pollution and related health risks in Nairobi Slums. Int J Environ Res Public Health. 2013;10(10):4851-68.
45. Guo Y, Liu F, Lu Y, Mao Z, Lu H, Wu Y, et al. Factors affecting parent's perception on air quality-from the individual to the community level. Int J Environ Res Public Health. 2016; 13(5): 493.
46. Crowe MJ. Toward a "definitional model" of public perceptions of air pollution. J Air Pollut Control Assoc. 1968;18(3):154-7.
47. Shi X, He F. The environmental pollution perception of residents in coal mining areas: a case study in the Hancheng mine area, Shaanxi Province, China. Environ Manage. 2012;50(4):505-13.
48. Charles E, Thomas DS, Dewey D, Davey M, Ngallaba SE, Konje E. A cross-sectional survey on knowledge and perceptions of health risks associated with arsenic and mercury contamination from artisanal gold mining in Tanzania. BMC Public Health. 2013;13:74.
49. Omanga E, Ulmer L, Berhane Z, Gatari M. Industrial air pollution in rural Kenya: community awareness, risk perception and associations between risk variables. BMC Public Health. 2014;14(1):377.
50. Laumbach R, Meng Q, Kipen H. What can individuals do to reduce personal health risks from air pollution?. J Thorac Dis. 2015;7(1):96-107.
51. Qian X, Xu G, Li L, Shen Y, He T, Liang Y, et al. Knowledge and perceptions of air pollution in Ningbo, China. BMC Public Health. 2016;16.

52. Zullig KJ, Hendryx M. A comparative analysis of health-related quality of life for residents of U.S. counties with and without coal mining. Public Health Rep. 2010;125(4):548-55.
53. Center of Excellence on Hazardous Substance Management, Chulalongkorn University. Silicosis. [Cited 2016 May 9]. Available from: http://www.chemtrack.org/ HazMap-Disease-Info.asp?ID= 188.
54. Martins P, Marchiori E, Zanetti G, Muccillo A, Ventura N, Brandão V, et al. Cavitated conglomerate mass in silicosis indicating associated tuberculosis. Case reports in medicine. 2010;2010
55. Guha N, Straif K, Benbrahim-Tallaa LJLMdl. The IARC Monographs on the carcinogenicity of crystalline silica. Med Lav. 2011;102(4):310-20.
56. Thakur SA, Beamer CA, Migliaccio CT, Holian A. Critical role of MARCO in crystalline silica-induced pulmonary inflammation. Toxicol Sci. 2009;108(2): 462-71.
57. Moondee S, Bualert S, Phewnil O, Jiamjarasragsi W. Prevalence of respiratory symptoms and lung function efficiency of students in rock-crushing industrial area, Saraburi Province. Proceedings of 44th Kasetsart University annual conference, Kasetsart University. 2006.
58. Anderson JO, Thundiyil JG, Stolbach A. Clearing the air: a review of the effects of particulate matter air pollution on human health. J Med Toxicol. 2012;8(2):166-75.
59. IARC Working Group on the Evaluation of Carcinogenic Risk to Humans. Outdoor Air Pollution. IARC Monogr Eval Carcinog Risks Hum. 2016;109:9-444.
60. Dockery DW. Health effects of particulate air pollution. Ann Epidemiol. 2009;19(4):257-63.
61. Wongtim S, Sridama V. Textbook of occupational Lung disease. 1999.
62. Franque Mirembo JC, Swanepoel AJ, Rees D. Respirable quartz exposure on two medium-sized farms in southern Mozambique. Int J Occup Environ Health. 2013;19(2):113-8.

63. Omidianidost A, Ghasemkhani M, Azari MR, Golbabaei F. Assessment of occupational exposure to dust and crystalline silica in foundries. Tanaffos. 2015;14(3):208-12.
64. Thomas RJ. Particle size and pathogenicity in the respiratory tract. Virulence. 2013;4(8):847-58.
65. D'Souza MS, Karkada SN, Somayaji G. Factors associated with health-related quality of life among Indian women in mining and agriculture. Health Qual Life Outcomes. 2013;11:9.
66. Mamuya SH, Bratveit M, Mashalla Y, Moen BE. High prevalence of respiratory symptoms among workers in the development section of a manually operated coal mine in a developing country: a cross sectional study. BMC Public Health. 2007;7:17.
67. Nordby KC, Fell AK, Noto H, Eduard W, Skogstad M, Thomassen Y, et al. Exposure to thoracic dust, airway symptoms and lung function in cement production workers. Eur Respir J. 2011;38(6):1278-86.
68. Healy CB, Coggins MA, Van Tongeren M, MacCalman L, McGowan P. Determinants of respirable crystalline silica exposure among stoneworkers involved in stone restoration work. Ann Occup Hyg. 2014;58(1):6-18.
69. Olusegun O, Adeniyi A, Adeola GT. Impact of granite quarrying on the health of workers and nearby residents in Abeokuta Ogun State, Nigeria. Ethiopian Journal of Environmental Studies and Management. 2009;2(1).
70. Briggs D, Corvalán C, Nurminen M. World Health Organization (WHO). Linkage methods for environment and health analysis: general guidelines: a report of the Health and Environment Analysis for Decision-making (HEADLAMP) project, 1996. [Cited 2016 May 9]. Available from: https://apps.who.int/iris/handle/10665/62988.
71. Darcin M. Association between air quality and quality of life. Environ Sci Pollut Res Int. 2014;21(3):1954-9.
72. Brunekreef B, Forsberg B. Epidemiological evidence of effects of coarse airborne particles on health. Eur Respir J. 2005;26(2):309-18.

73. Guo Y, Li S, Tawatsupa B, Punnasiri K, Jaakkola JJ, Williams G. The association between air pollution and mortality in Thailand. Sci Rep. 2014;4:5509.
74. Xu X, Sharma RK, Talbott EO, Zborowski JV, Rager J, Arena VC, et al. PM_{10} air pollution exposure during pregnancy and term low birth weight in Allegheny County, PA, 1994-2000. Int Arch Occup Environ Health. 2011;84(3):251-7.
75. The International Labour Organization (ILO). Guidelines for the use of the ILO international classification of radiographs of pneumoconiosis, 2011. [Cited 2016 May 9]. Available from: https://www.ilo. org /safework/info/publications/ WCMS_168260/lang--en/index. htm.
76. Torres Rey CH, Ibañez Pinilla M, Briceño Ayala L, Checa Guerrero DM, Morgan Torres G, Groot de Restrepo H, et al. Underground coal mining: relationship between coal dust levels and pneumoconiosis, in two regions of Colombia, 2014. Biomed Res Int. 2015;647878.
77. Ross MH, Murray J. Occupational respiratory disease in mining. Occup Med (Lond). 2004;54(5):304-10.
78. Rees D, Murray J. Silica, silicosis and tuberculosis. Int J Tuberc Lung Dis. 2007;11(5):474-84.
79. Milovanovic A, Nowak D, Milovanovic A, Hering KG, Kline JN, Kovalevskiy E, et al. Silicotuberculosis and silicosis as occupational diseases: report of two cases. Srpski arhiv za celokupno lekarstvo. 2011;139(7-8):536-9.
80. Chaisabai A. Dust exposure and signs and symptoms of respiratory system and lung function in tied garlic and shallot workers in Lamphun Province [Thesis Master of Public Health. Graduate School]. Chiang Mai: Chiang Mai University; 2012.
81. The Association of Occupational and Environmental Diseases of Thailand and Occupational and Environmental Medical Center, Nopparat Rajathanee Hospital. Guideline for standardization and interpretation of pulmonary function test by spirometry in occupational health setting, 2018. [Cited 2016 May 9]. Available from: http://safetyhubs.com/wp-content/uploads/2018/11/book_spirometry.pdf.
82. Buranatrevedh S. Textbook of Occupational Medicine. 1st editor. Bangkok: Booknet Press; 2004.

83. Nambunmee K., Songlar T, Kongkratoke S, Cassely M, Niruksanti W. Biological markers application in silicosis risk screening. Thai Journal of Toxicology. 2015;30(1):92-104.
84. Ruchirawat M, Navasumrit P, Kampeerawipakorn O, Promvijit J, Parnlob V. Potential health effects of exposure to carcinogenic volatile organic compounds of people in Rayong Province, Thailand, 2010. [Cited 2016 May 9]. Available from: https://elibrary.trf.or.th/project_content.asp?PJID=RDG5030035.
85. Eom H-J, Choi J. Oxidative stress of silica nanoparticles in human bronchial epithelial cell, Beas-2B. Toxicology in vitro. Toxicol In Vitro. 2009;23(7):1326-32.
86. Anlar HG, Bacanli M, Iritas S, Bal C, Kurt T, Tutkun E, et al. Effects of occupational silica exposure on oxidative stress and immune system parameters in ceramic workers in Turkey. J Toxicol Environ Health A. 2017;80(13-15):688-96.
87. Wang SX, Liu P, Wei MT, Chen L, Guo Y, Wang RY, et al. Roles of serum clara cell protein 16 and surfactant protein-D in the early diagnosis and progression of silicosis. J Occup Environ Med. 2007;49(8):834-9.
88. Snyder JC, Reynolds SD, Hollingsworth JW, Li Z, Kaminski N, Stripp BR. Clara cells attenuate the inflammatory response through regulation of macrophage behavior. Am J Respir Cell Mol Biol. 2010;42(2):161-71.
89. Deguen S, Segala C, Pedrono G, Mesbah M. A new air quality perception scale for global assessment of air pollution health effects. Risk Anal. 2012;32(12):2043-54.
90. Kumpiranont R, Supaporn S, Sukkasame N. Perception and environmental change on health impact among people living around the mining industry area, Chonburi Province. J Public Health. 2011;41(3):219.
91. Madungwe E, Mukonzvi T. Assessment of distribution and composition of quarry mine dust: Case of Pomona Stone Quarries, Harare. Atmos and Climate Sci. 2012;2(01), 52.
92. Severtson DJ, Burt JE. The influence of mapped hazards on risk beliefs: A proximity-based modeling approach. Risk Anal. 2012;32(2):259-80.

93. Pu S, Shao Z, Fang M, Yang L, Liu R, Bi J, et al. Spatial distribution of the public's risk perception for air pollution: A nationwide study in China. Sci Total Environ. 2019;655:454-62.
94. Sajjadi SA, Zolfaghari G, Adab H, Allahabadi A, Delsouz M. Measurement and modeling of particulate matter concentrations: Applying spatial analysis and regression techniques to assess air quality. MethodsX. 2017;4:372-90.
95. Deguen S, Pédrono G, Segala C, Mesbah M. Association between pollution and public perception of air quality-SEQAP, a risk perception study in France. Epidemiology. 2008;19(6):S216.
96. Badland HM, Duncan MJ. Perceptions of air pollution during the work-related commute by adults in Queensland, Australia. Atmos Environ. 2009;43(36):5791-5.
97. Pokawinpudisnun R, Chanprasit C, Songkham W. Dust hazard risk perception and protection behaviors among ceramic factory workers. J Health Sci. 2009;18(4):587-96.
98. Geer LA, Curbow BA, Anna DH, Lees PS, Buckley TJ. Development of a questionnaire to assess worker knowledge, attitudes and perceptions underlying dermal exposure. Scand J Work Environ Health. 2006;32(3):209-18.
99. World Health Organization (WHO). The WHO health promotion glossary, 1998. [Cited 2016 May 9]. Available from: http://www.who.int/healthpromotion/about/HPG/en/.
100. Ahmed HO, Abdullah AA. Dust exposure and respiratory symptoms among cement factory workers in the United Arab Emirates. Ind Health. 2012;50(3):214-22.
101. Siripanich S, Siriwong W, Keawrueang P, Borjan M, Robson M. Incense and joss stick making in small household factories, Thailand. Int J Occup Environ Med. 2014;5(3):137-45.
102. Pothirat C, Chaiwong W, Liwsrisakun C, Bumroongkit C, Deesomchok A, Theerakittikul T, et al. Influence of particulate matter during seasonal smog on quality of life and lung function in patients with chronic obstructive pulmonary disease. Int J Environ Res Public Health. 2019;16(1).

103.Fleury-Bahi G, Préau M, Annabi-Attia T, Marcouyeux A, Wittenberg I. Perceived health and quality of life: the effect of exposure to atmospheric pollution. J Risk Res. 2015;18(2):127-38.

104.Tanser FC, le Sueur D. The application of geographical information systems to important public health problems in Africa. Int J Health Geogr. 2002;1:4.

105.McCracken DS, Allen DA, Gow AJ. Associations between urban greenspace and health-related quality of life in children. Prev Med Rep. 2016;3:211-21.

106.Thornton LE, Pearce JR, Kavanagh AM. Using geographic information systems (GIS) to assess the role of the built environment in influencing obesity: a glossary. Int J Behav Nutr Phys Act. 2011;8:71.

107.Wang W, Ying Y, Wu Q, Zhang H, Ma D, Xiao W. A GIS-based spatial correlation analysis for ambient air pollution and AECOPD hospitalizations in Jinan, China. Respir Med. 2015;109(3):372-8.

108.Ware JE Jr, Gandek B. Overview of the SF-36 health survey and the international quality of life assessment (IQOLA) project. J Clin Epidemiol. 1998;51(11):903-12.

109.Leurmarnkul W, Meetam P. Properties Testing of the Retranslated SF-36 (Thai Version). Thai J Pharm Sci. 2005;29:69-88.

110.Nedjat S, Montazeri A, Holakouie K, Mohammad K, Majdzadeh R. Psychometric properties of the Iranian interview-administered version of the World Health Organization's Quality of Life Questionnaire (WHOQOL-BREF): a population-based study. BMC Health Serv Res. 2008;8:61.

111.Jenkinson C, Stewart-Brown S, Petersen S, Paice C. Assessment of the SF-36 version 2 in the United Kingdom. J Epidemiol Community Health. 1999;53(1):46-50.

112.Yamazaki S, Nitta H, Murakami Y, Fukuhara S. Association between ambient air pollution and health-related quality of life in Japan: ecological study. Int J Environ Health Res. 2005;15(5):383-91.

113.Liu HB, Yan B, Han B, Sun JK, Yang Y, Chen J. Determination of ameliorable health impairment influencing health-related quality of life among patients with silicosis in China: a cross-sectional study. J Int Med Res. 2011;39(4):1448-55.

114. Zullig KJ, Hendryx M. Health-related quality of life among central appalachian residents in mountaintop mining counties. Am J Public Health. 2011;101(5):848-53.

115. Han B, Yan B, Zhao N, Zhang J, Sun J, Lei X, et al. The influence of the functional capacity on subjective well-being and quality of life of patients with silicosis. Aging Ment Health. 2013;17(6):707-13.

116. Pongtap Vivantanadej. Health risk assessment. 1st editor. Chiang Mai: Community Medicine Press; 2004.

117. International Agency for Research on Cancer (IARC). IARC Monographs on the evaluation of carcinogenic risks to humans, 1997. [Cited 2016 May 9]. Available from: http://monographs.iarc.fr/ENG/ Monographs/vol68/index.php.

118. Coughlin SS, Chiazze LJr. Job-exposure matrices in epidemiologic research and medical surveillance. Occup Med. 1990;5(3):633-46.

119. Sieber K, Seta J, Young R, editors. A job exposure matrix for identification of potential exposures in occupational settings. 9th International Symposium: Epidemiology in Occupational Health, Cincinnati, Ohio; 1992.

120. Goldberg M, Kromhout H, Guenel P, Fletcher AC, Gerin M, Glass DC, et al. Job exposure matrices in industry. Int J Epidemiol. 1993;22 Suppl 2:S10-5.

121. Kauppinen T, Toikkanen J, Pukkala E. From cross-tabulations to multipurpose exposure information systems: A new job-exposure matrix. Am J Ind Med. 1998;33(4):409-17.

122. Benke G, Sim M, Fritschi L, Aldred G. Beyond the job exposure matrix (JEM): the task exposure matrix (TEM). Ann Occup Hyg. 2000;44(6):475-82.

123. US Environmental Protection Agency (US EPA). Risk assessment guidance for superfund volume 1: human health evaluation manual (Part A). 1989;EPA/540/1-89/002.

124. Ministry of Public Health, Department of Health. Guidelines for monitoring air pollution in risk areas: small particulate matter, 2015. [Cited 2016 May 9]. Available from: http://hia.anamai.moph.go.th/more_news.php?cid=317& filename=index.

125.National Institute for Occupational Safety and Health (NIOSH). Manual of Analytical Methods: 0600, Particulates not otherwise regulated, respirable. 4, editor, 1998. [Cited 2016 May 9]. Available from: https://www.cdc.gov/niosh /docs/ 2003-154/pdfs/0600.pdf.

126.National Institute for Occupational Safety and Health (NIOSH). Manual of Analytical Methods: 7601, Silica, Crystalline, by VIS. 4, editor, 2003. [Cited 2016 May 9]. Available from: https://www.cdc.gov/niosh/docs/2003-154/pdfs/ 7601.pdf.

127.Occupational Safety and Health Administration (OSHA). Permissible exposure limits, 2018. [Cited 2016 May 9]. Available from: https://www.osha.gov/dsg/ annotated-pels/tablez-1.html.

128.Helsing KJ, Comstock GW, Speizer FE, Ferris BG, Lebowitz MD, Tockman MS, et al. Comparison of three standardized questionnaires on respiratory symptoms. Am Rev Respir Dis. 1979;120(6):1221-31.

129.Miller MR, Hankinson J, Brusasco V, Burgos F, Casaburi R, Coates A, et al. Standardisation of spirometry. Eur Respir J. 2005;26(2):319-38.

130.Dejsomritrutai W, Nana A, Maranetra KN, Chuaychoo B, Maneechotesuwan K, Wongsurakiat P, et al. Reference spirometric values for healthy lifetime nonsmokers in Thailand. J Med Assoc Thai. 2000;83(5):457-66.

131.Pellegrino R, Viegi G, Brusasco V, Crapo RO, Burgos F, Casaburi R, et al. Interpretative strategies for lung function tests. Eur Respir J. 2005;26(5):948-68.

132.R Development Core Team. R: a language and environment for statistical computing, 2015. [Cited 2016 May 9]. Available from: http://.R-project.org.

133.Ngamjarus C. n4Studies: sample size calculation for an epidemiological study on a smart device. Siriraj Medical Journal, 2016, 68.3: 160-170.

134.Wayne WD. Biostatistics: A Foundation of Analysis in the Health Sciences, 6th edition. New York: Wiley & Sons; 1995.

135.Ware JE, Gandek B. The SF-36 Health Survey: development and use in mental health research and the IQOLA Project. Intl J Mental Health. 1994:49-73.

136.Ware JE Jr, Kosinski M, Bayliss MS, McHorney CA, Rogers WH, Raczek A. Comparison of methods for the scoring and statistical analysis of SF-36 health profile and summary measures: summary of results from the Medical Outcomes Study. Med Care. 1995;33(4 Suppl):As264-79.
137.Jirarattanaphochai K, Jung S, Sumananont C, Saengnipanthkul S. Reliability of the medical outcomes study short-form survey version 2.0 (Thai version) for the evaluation of low back pain patients. J Med Assoc Thai. 2005;88(10):1355-61.
138.Hearl FJ. Current exposure guidelines for particulates not otherwise classified or regulated: History and rationale. Appl Occup Environ Hyg. 1998;13(8):608-12.
139.Lim LL, Seubsman SA, Sleigh A. Thai SF-36 health survey: tests of data quality, scaling assumptions, reliability and validity in healthy men and women. Health Qual Life Outcomes. 2008;6:52.
140.Nambunmee K, Danphaiboon A, Khantipongse J. Increased serum heme oxygenase-1 in silicosis-suspected subjects from limestone crusher factories. J Health Res. 2014;28(1).
141.Chanvirat K, Chaiear N, Choosong T. Determinants of respirable crystalline silica exposure among sand-stone workers. Am J Public Health Res. 2018;6(2):44-50.
142.Chaiear N, Trakultaweesuk P, Boonsawat W. Occupational respirable cystalline silica exposure related to fev1 decline among normal or early abnormal ilo chest-radiographs of sandstone-workers; a six month follow up. Occup Environ Med. 2017;74(Suppl 1):A69-A.
143.Mohammadi H, Farhang Dehghan S, Golbabaei F, Roshani S, Pakzad R, Foroughi P, et al. Pulmonary functions and health-related quality of life among silica-exposed workers. Tanaffos. 2017;16(1):60-7.
144.Bhagia LJ. Non-occupational exposure to silica dust. Indian J Occup Environ Med. 2012;16(3):95-100.
145.Kuo CT, Chiu FF, Bao BY, Chang TY. Determination and prediction of respirable dust and crystalline-free silica in the Taiwanese foundry industry. Int J Environ Res Public Health. 2018;15(10). pii: E2105.

146. Sivacoumar R, Jayabalou R, Subrahmanyam YV, Jothikumar N, Swarnalatha S. Air pollution in stone crushing industry, and associated health effects. Indian J Environ Health. 2001;43(4):169-73.
147. Sun Z, An X, Tao Y, Hou Q. Assessment of population exposure to PM_{10} for respiratory disease in Lanzhou (China) and its health-related economic costs based on GIS. BMC Public Health. 2013;13:891.
148. Isara AR, Adam VY, Aigbokhaode AQ, Alenoghena IO. Respiratory symptoms and ventilatory functions among quarry workers in Edo state, Nigeria. Pan Afr Med J. 2016;23:212.
149. Yingratanasuk T, Seixas N, Barnhart S, Brodkin D. Respiratory health and silica exposure of stone carvers in Thailand. Int J Occup Environ Health. 2002;8(4):301-8.
150. Garshick E, Laden F, Hart JE, Caron A. Residence near a major road and respiratory symptoms in U.S. Veterans. Epidemiology. 2003;14(6):728-36.
151. Doiron D, de Hoogh K, Probst-Hensch N, Mbatchou S, Eeftens M, Cai Y, et al. Residential Air Pollution and Associations with Wheeze and Shortness of Breath in Adults: A Combined Analysis of Cross-Sectional Data from Two Large European Cohorts. Environ Health Perspect. 2017;125(9):097025.
152. Hertzberg VS, Rosenman KD, Reilly MJ, Rice CH. Effect of occupational silica exposure on pulmonary function. Chest. 2002;122(2):721-8.
153. Lamichhane DK, Leem JH, Kim HC. Associations between ambient particulate matter and nitrogen dioxide and chronic obstructive pulmonary diseases in adults and effect modification by demographic and lifestyle factors. Int J Environ Res Public Health. 2018;15(2). pii: E363.
154. Aghilinejad M, Naserbakht A, Naserbakht M, Attari G. Silicosis among stone-cutter workers: A cross-sectional study. Tanaffos. 2012;11(2):38-41.
155. Fubini B, Hubbard A. Reactive oxygen species (ROS) and reactive nitrogen species (RNS) generation by silica in inflammation and fibrosis. Free Radic Biol Med. 2003;34(12):1507-16.
156. Silanun K. Development of a disease surveillance system for silicosis and respiratory disorders in stone carving workers in Thailand. Occup Environ Med. 2014;71(Suppl 1):A117-A.

157.Broeckaert F, Clippe A, Knoops B, Hermans C, Bernard A. Clara cell secretory protein (CC16): features as a peripheral lung biomarker. Annals of the New York Academy of Sciences. 2000;923(1):68-77.
158.Xiao C, Li S, Zhou W, Shang D, Zhao S, Zhu X, et al. The effect of air pollutants on the microecology of the respiratory tract of rats. Environ Toxicol Pharmacol. 2013;36(2):588-94.
159.Hermans C, Petrek M, Kolek V, Weynand B, Pieters T, Lambert M, et al. Serum Clara cell protein (CC16), a marker of the integrity of the air-blood barrier in sarcoidosis. Eur Respir J. 2001;18(3):507-14.
160.Albrecht C, Adolf B, Weishaupt C, Höhr D, Zeitträger I, Friemann J, et al. Clara-cell hyperplasia after quartz and coal-dust instillation in rat lung. Inhal Toxicol. 2001;13(3):191-205.
161.Nagatomo H, Morimoto Y, Oyabu T, Hirohashi M, Ogami A, Yamato H, et al. Expression of heme oxygenase-1 in the lungs of rats exposed to crystalline silica. J Occup Health. 2006;48(2):124-8.
162.Maestrelli P, El Messlemani AH, De Fina O, Nowicki Y, Saetta M, Mapp C, et al. Increased expression of heme oxygenase (HO)-1 in alveolar spaces and HO-2 in alveolar walls of smokers. Am J Respir Crit Care Med. 2001;164(8):1508-13.
163.Zhou H, Lu F, Latham C, Zander DS, Visner GA. Heme oxygenase-1 expression in human lungs with cystic fibrosis and cytoprotective effects against pseudomonas aeruginosa in vitro. Am J Respir Crit Care Med. 2004;170(6):633-40.
164.Bao W, Song F, Li X, Rong S, Yang W, Zhang M, et al. Plasma heme oxygenase-1 concentration is elevated in individuals with type 2 diabetes mellitus. PLoS One. 2010;5(8):e12371.
165.Abbey DE, Hwang BL, Burchette RJ, Vancuren T, Mills PK. Estimated long-term ambient concentrations of PM10 and development of respiratory symptoms in a nonsmoking population. Arch Environ Health. 1995;50(2):139-52.
166.Goldberg MJRoeh. A systematic review of the relation between long-term exposure to ambient air pollution and chronic diseases. 2008;23(4):243-98.

167.Kusaka T, Nakayama M, Nakamura K, Ishimiya M, Furusawa E, Ogasawara KJPo. Effect of silica particle size on macrophage inflammatory responses. 2014;9(3):e92634.
168.Pandey JK, Agarwal D. Biomarkers: A potential prognostic tool for silicosis. Indian J Occup Environ Med. 2012;16(3):101-7.
169.Chakraborty J, Collins TW, Grineski SE, Maldonado A. Racial Differences in Perceptions of Air Pollution Health Risk: Does Environmental Exposure Matter? Int J Environ Res Public Health. 2017;14(2):116.
170.Janmaimool P, Watanabe T. Evaluating Determinants of Environmental Risk Perception for Risk Management in Contaminated Sites. Int J Environ Res Public Health. 2014;11(6):6291-313.
171.Brender JD, Maantay JA, Chakraborty J. Residential proximity to environmental hazards and adverse health outcomes. Am J Public Health. 2011;101(S1):S37-S52.
172.Orru K, Nordin S, Harzia H, Orru H. The role of perceived air pollution and health risk perception in health symptoms and disease: a population-based study combined with modelled levels of PM_{10}. Int Arch Occup Environ Health. 2018;91(5):581-9.
173.Pattinson W, Longley I, Kingham S. Proximity to busy highways and local resident perceptions of air quality. Health & Place. 2015;31:154-62.
174.Li Z, Folmer H, Xue J. Perception of air pollution in the Jinchuan Mining Area, China: A Structural Equation Modeling Approach. Int J Environ Res Public Health. 2016;13(5).
175.Laumbach RJ, Kipen HM. Respiratory health effects of air pollution: update on biomass smoke and traffic pollution. J Allergy Clin Immunol. 2012;129(1):3-11; quiz 2-3.
176.Wang R, Wu C, Zhao Y, Yan X, Ma X, Wu M, et al. Health related quality of life measured by SF-36: a population-based study in Shanghai, China. BMC Public Health. 2008;8:292.
177.Laurent O, Bard D, Filleul L, Segala C. Effect of socioeconomic status on the relationship between atmospheric pollution and mortality. J Epidemiol Community Health. 2007;61(8):665-75.

178. Krewski D. Evaluating the effects of ambient air pollution on life expectancy. N Engl J Med. 2009;360(4):413-5.
179. Lee MK, Choi JY, Kim IK, Cho YA, Kim YS, Jung HJ, et al. Does living nearby a garbage dumping site degrade the quality of life? A case study based on Shin-dong Myeon residents, Chun-cheon Si. J Prev Med Public Health. 2006;39(4):302-8.
180. Balmes JR, Earnest G, Katz PP, Yelin EH, Eisner MD, Chen H, et al. Exposure to traffic: Lung function and health status in adults with asthma. J Allergy Clin Immunol. 2009;123(3):626-31.
181. Roswall N, Høgh V, Envold-Bidstrup P, Raaschou-Nielsen O, Ketzel M, Overvad K, et al. Residential exposure to traffic noise and health-related quality of life-a population-based study. PLoS One. 2015;10(3).
182. Yang J, Nam I, Yun H, Kim J, Oh H-J, Lee D, et al. Characteristics of indoor air quality at urban elementary schools in Seoul, Korea: Assessment of effect of surrounding environments. Atmos Pollut Res. 2015;6(6):1113-22.
183. Guerra SA, Lane DD, Marotz GA, Carter RE, Hohl CM, Baldauf RW. Effects of wind direction on coarse and fine particulate matter concentrations in southeast Kansas. J Air Waste Manag Assoc. 2006;56(11):1525-31.

LIST OF PUBLICATIONS

1. Sakesun Thongtip, Penprapa Siviroj, Athavudh Deesomchok, Anawat Wisetborisut, Tippawan Prapamontol. Association of health-related quality of life with residential distance from home stone-mortar factories in Northern Thailand. EnvironmentAsia Journal. 2019; 12 (3).
2. Sakesun Thongtip, Penprapa Siviroj, Athavudh Deesomchok, Tippawan Prapamontol, Anawat Wisetborisut, Supakit Khacha-ananda. Effect of high silica exposure on respiratory disorders among stone-mortar workers in Northern Thailand. the Southeast Asian Journal of Tropical Medicine and Public Health. 2019; 50(2).

APPENDICES

APPENDIX A

QUESTIONNAIRE

แบบสอบถาม

เรื่อง การรับรู้ความเสี่ยง พฤติกรรมการป้องกันการสัมผัสฝุ่นซิลิกา
อาการของระบบทางเดินหายใจ และคุณภาพชีวิตของผู้ประกอบอาชีพทำครกหิน

คำชี้แจง แบบสัมภาษณ์ประกอบไปด้วย 8 ส่วน ดังนี้

ส่วนที่ 1 ข้อมูลทั่วไป ส่วนที่ 2 ประวัติการทำงาน
ส่วนที่ 3 พฤติกรรมสุขภาพ ส่วนที่ 4 ประวัติการเจ็บป่วย
ส่วนที่ 5 การรับรู้ความเสี่ยงเกี่ยวกับมลพิษอากาศและผลกระทบต่อสุขภาพ
ส่วนที่ 6 พฤติกรรมการป้องกันการสัมผัสฝุ่นซิลิกา
ส่วนที่ 7 อาการของระบบทางเดินหายใจ
ส่วนที่ 8 คุณภาพชีวิต

ส่วนที่ 1 ข้อมูลทั่วไป

1. วันที่ทำแบบสอบถาม .... (วัน / เดือน / ปี)
2. วันเกิด (วัน / เดือน / ปี) ....
3. หมู่ที่ ....
4. น้ำหนักตัว .... กิโลกรัม
5. ส่วนสูง................................ เซนติเมตร
6. อายุ .... ปี
7. เพศ .... ชาย .... หญิง
8. ระดับการศึกษา
.... ประถมศึกษา .... มัธยมศึกษาตอนต้น .... มัธยมศึกษาตอนปลาย
.... ปวช. .... ปวส. .... ปริญญาตรี
.... สูงกว่าปริญญาตรี .... อื่นๆ โปรดระบุ ....

9. สถานภาพ

.... โสด .... แต่งงาน.......... หย่าร้าง .... แยกกันอยู่

.... อื่นๆ โปรดระบุ ....

10. อาชีพหลัก .... อื่นๆ โปรดระบุ ....

11. ระยะเวลาอาศัยอยู่ในพื้นที่ .... ปี

12. รายได้เฉลี่ยต่อเดือน .... บาท

ส่วนที่ 2 ประวัติการทำงาน

1. เริ่มประกอบอาชีพครกหิน ตั้งแต่ปี พ.ศ. .... เป็นระยะเวลาทำงานถึงปัจจุบัน ...... ปี

2. ตำแหน่งทำงานอยู่ในขั้นตอนการทำงาน (เลือกได้มากกว่า 1 ข้อ)

.... หาวัตถุดิบที่ใช้ทำครกหิน .... ทำการเจาะหรือแล่งให้เป็นรูปหุ่นครกหิน

.... กระบวนการตัดให้เป็นรูป .... กระบวนการกลึงให้เป็นรูปครกหิน

.... อื่นๆ โปรดระบุ ....

3. เริ่มทำงานเวลา ตั้งแต่ .... โมง จนถึง .... โมง

4. ระยะเวลาทำงาน เฉลี่ย .... ชั่วโมง/วัน .... วัน/สัปดาห์ ..... วัน/เดือน .... วัน/ปี

ส่วนที่ 3 พฤติกรรมสุขภาพ

1. การสูบบุหรี่

1.1 ปัจจุบันท่านสูบบุหรี่หรือไม่ .... 1. ใช่ .... 2. ไม่ใช่

1.2 จำนวนบุหรี่ที่ท่านสูบบุหรี่ในแต่ละวัน ในปัจจุบัน .... มวน/วัน

2. ปัจจุบันท่านดื่มสุราหรือแอลกอฮอล์ .... 1. ใช่ .... 2. ไม่ใช่

ส่วนที่ 4 ประวัติการเจ็บป่วย

1. ท่านเคยได้รับการวินิจฉัยโรคจากแพทย์หรือสถานพยาบาล

ชื่อโรค	ไม่เคย	เคยเป็น (หายแล้ว)	เป็น (ยังไม่ได้รักษา)	เป็น (กำลังรักษา)	ไม่แน่ใจ
1. โรคหลอดลมอักเสบ					
2. โรคถุงลมโป่งพอง					
3. โรคหอบหืด					

ชื่อโรค	ไม่เคย	เคยเป็น (หายแล้ว)	เป็น (ยังไม่ได้รักษา)	เป็น (กำลังรักษา)	ไม่แน่ใจ
4. โรคภูมิแพ้					
5. โรควัณโรคปอด					
6. โรคหัวใจ					
7. โรคความดันโลหิตสูง					
8. โรคจมูกอักเสบจากการแพ้					
9. โรคข้ออักเสบ					
10. โรคเบาหวาน					
11. โรคทางประสาท					
12. โรคแพ้ภูมิตนเอง					
13. โรคหลอดเลือด					
14. โรคปอดอื่นๆ (ปอดอักเสบ / ปอดอุดกั้นเรื้อรัง) ระบุ					
15. โรคมะเร็ง (มะเร็งปอด) ระบุ…………..					
16. การบาดเจ็บ / ผ่าตัดทรวงอก					
17. โรคอัลไซเมอร์					
18. โรคตับและตับอักเสบ					
19. โรคทางจิต					

2. ท่านมีโรคประจำตัวอื่นๆ .... มี ระบุ .... ไม่มี

ส่วนที่ 5 การรับรู้ความเสี่ยงเกี่ยวกับมลพิษอากาศและผลกระทบต่อสุขภาพจากพื้นที่ประกอบอาชีพทำครกหิน

ลำดับ	คำถาม	**ความคิดเห็น** ตลอดสัปดาห์ที่ผ่านมา เนื่องด้วยผลของมลพิษอากาศและผลกระทบต่อสุขภาพจากการสัมผัสฝุ่นครกหิน ฝุ่นหิน ฝุ่นซิลิกา คุณมี			
		ไม่เคย 0 ครั้งต่อสัปดาห์	**บางครั้ง** 1-2 ครั้งต่อสัปดาห์	**บ่อยครั้ง** 3-5 ครั้งต่อสัปดาห์	**ตลอดเวลา** ≥6 ครั้งต่อสัปดาห์
1	ความรู้สึกกังวล จากฝุ่นครกหิน ฝุ่นหิน เกี่ยวกับสุขภาพของท่าน หรือไม่				
2	มีตาแดง จากฝุ่นครกหิน ฝุ่นหิน หรือไม่				
3	ทรมานจากการระคายเคืองจมูก จากฝุ่นครกหิน ฝุ่นหิน หรือไม่				
4	มีอาการจาม จากฝุ่นครกหิน ฝุ่นหิน หรือไม่				
5	มีคอแห้ง จากฝุ่นครกหิน ฝุ่นหิน หรือไม่				
6	มีไอ จากฝุ่นครกหิน ฝุ่นหิน หรือไม่				
7	มีหายใจลำบาก จากฝุ่นครกหิน ฝุ่นหิน หรือไม่				
8	ทรมานจากอาการปวดหัว จากฝุ่นครกหิน ฝุ่นหิน หรือไม่				

ลำดับ	คำถาม	ความคิดเห็น ตลอดสัปดาห์ที่ผ่านมา เนื่องด้วยผลของมลพิษอากาศและผลกระทบต่อสุขภาพจากการสัมผัสฝุ่นครกหิน ฝุ่นหิน ฝุ่นซิลิกา คุณมี			
		ไม่เคย 0 ครั้งต่อสัปดาห์	**บางครั้ง** 1-2 ครั้งต่อสัปดาห์	**บ่อยครั้ง** 3-5 ครั้งต่อสัปดาห์	**ตลอดเวลา** $\geq$6 ครั้งต่อสัปดาห์
9	มีการเปลี่ยนกิจกรรมยามว่าง จากฝุ่นครกหิน ฝุ่นหิน หรือไม่ (เช่น ออกไปเดินเล่น หรือออกกำลังกาย เป็นต้น)				
10	อยู่ในบ้าน ได้รับผลของมลพิษอากาศ จากฝุ่นครกหิน ฝุ่นหิน หรือไม่				
11	อากาศที่บ้าน ได้รับผลของมลพิษอากาศ จากฝุ่นครกหิน ฝุ่นหิน หรือไม่				
12	มีการปิดประตูหน้าต่างในบ้าน จากฝุ่นครกหิน ฝุ่นหิน หรือไม่				
13	ใช้เครื่องฟอกอากาศให้สดชื่นในบ้าน จากฝุ่นครกหิน ฝุ่นหิน หรือไม่				
14	หลีกเลี่ยงการเปิดหน้าต่างของท่าน จากฝุ่นครกหิน ฝุ่นหิน หรือไม่				
15	รู้สึกว่า ต้องล้างมือหรือใบหน้า จากฝุ่นครกหิน ฝุ่นหิน หรือไม่				

ลำดับ	คำถาม	ความคิดเห็น ตลอดสัปดาห์ที่ผ่านมา เนื่องด้วยผลของมลพิษอากาศและผลกระทบต่อสุขภาพจากการสัมผัสฝุ่นครกหิน ฝุ่นหิน ฝุ่นซิลิกา คุณมี			
		ไม่เคย 0 ครั้งต่อสัปดาห์	**บางครั้ง** 1-2 ครั้งต่อสัปดาห์	**บ่อยครั้ง** 3-5 ครั้งต่อสัปดาห์	**ตลอดเวลา** $\geq$6 ครั้งต่อสัปดาห์
16	ดื่มน้ำมากขึ้นกว่าปกติ จากฝุ่นครกหิน ฝุ่นหิน หรือไม่				
17	มีกลิ่นที่ไม่พึงประสงค์ หรือกลิ่นจากภายนอกบ้าน จากฝุ่นครกหิน ฝุ่นหิน หรือไม่				
18	มีกลิ่นที่ไม่พึงประสงค์ หรือกลิ่นจากภายในบ้าน จากฝุ่นครกหิน ฝุ่นหิน หรือไม่				
19	สังเกตเห็นผ้าม่านของท่านเปื้อน จากฝุ่นครกหิน ฝุ่นหิน หรือไม่				
20	สังเกตเห็นว่าท้องฟ้ามืดมัวด้วยมลพิษอากาศ จากฝุ่นครกหิน ฝุ่นหิน หรือไม่				
21	คุณภาพชีวิตของท่านลดลง จากฝุ่นครกหิน ฝุ่นหิน หรือไม่				
22	คิดเกี่ยวกับการย้ายบ้าน จากฝุ่นครกหิน ฝุ่นหิน หรือไม่				

ส่วนที่ 6 พฤติกรรมการป้องกันการสัมผัสจากฝุ่นครกหิน ฝุ่นหิน ฝุ่นซิลิกา

ลำดับ	คำถาม	คำตอบ				
		ไม่เคย 0 ครั้งต่อสัปดาห์	เป็นครั้งคราว 1-2 ครั้งต่อสัปดาห์	บางครั้ง 3-4 ครั้งต่อสัปดาห์	บ่อย 5-6 ครั้งต่อสัปดาห์	เป็นประจำ 7 ครั้งต่อสัปดาห์ / ทุกวัน
1	ท่านเดินหนีทุกครั้ง เมื่อมีมลพิษอากาศจากฝุ่นครกหิน ฝุ่นหิน หรือไม่					
2	ท่านสวมหน้ากากทุกครั้ง เมื่อมีมลพิษอากาศจากฝุ่นครกหิน ฝุ่นหิน หรือไม่					
3	ท่านแขวนผ้าทุกครั้ง เมื่อมีมลพิษอากาศจากฝุ่นครกหิน ฝุ่นหิน หรือไม่					
4	ท่านสวมอุปกรณ์ป้องกันอันตรายส่วนบุคคล (PPE) ตามคำแนะนำหรือขั้นตอนที่ถูกต้องทุกครั้ง เมื่อมีมลพิษอากาศจากฝุ่นครกหิน ฝุ่นหิน หรือไม่					
5	ท่านสวมใส่หน้ากากป้องกันฝุ่นชนิด N95 เมื่อมีมลพิษอากาศจากฝุ่นครกหิน ฝุ่นหิน หรือไม่					
6	ท่านสวมใส่อุปกรณ์ป้องกันอันตรายส่วนบุคคล (PPE) ตลอดเวลาทำงาน เมื่อมีมลพิษอากาศจากฝุ่นครกหิน ฝุ่นหิน หรือไม่หรือไม่					

ลำดับ	คำถาม	คำตอบ				
		ไม่เคย 0 ครั้งต่อสัปดาห์	เป็นครั้งคราว 1-2 ครั้งต่อสัปดาห์	บางครั้ง 3-4 ครั้งต่อสัปดาห์	บ่อย 5-6 ครั้งต่อสัปดาห์	เป็นประจำ 7 ครั้งต่อสัปดาห์ / ทุกวัน
7	เมื่อท่านไม่ได้ใช้อุปกรณ์ป้องกันอันตรายส่วนบุคคล (PPE) ท่านเก็บไว้ในที่แห้ง สะอาด ไม่มีมลพิษอากาศจากฝุ่นครกหิน ฝุ่นหิน หรือไม่					
8	ท่านร้องเรียนปัญหาทุกครั้ง เมื่อมีมลพิษอากาศจากฝุ่นครกหิน ฝุ่นหิน หรือไม่					
9	ท่านมีความรู้เพียงพอต่อการป้องกันตนเองทุกครั้ง เมื่อมีมลพิษอากาศจากฝุ่นครกหิน ฝุ่นหิน หรือไม่					
10	ท่านได้รับความรู้จากหน่วยงานภายนอกต่อการป้องกันตนเองทุกครั้ง เมื่อมีมลพิษอากาศจากฝุ่นครกหิน ฝุ่นหิน หรือไม่					
11	ท่านดื่มน้ำ ในพื้นที่ที่มีมลพิษอากาศจากฝุ่นครกหิน ฝุ่นหิน หรือไม่					
12	ท่านรับประทานอาหารหรือขนมในพื้นที่ที่มีมลพิษอากาศจากฝุ่นครกหิน ฝุ่นหิน หรือไม่					

ลำดับ	คำถาม	คำตอบ				
		ไม่เคย 0 ครั้งต่อสัปดาห์	เป็นครั้งคราว 1-2 ครั้งต่อสัปดาห์	บางครั้ง 3-4 ครั้งต่อสัปดาห์	บ่อย 5-6 ครั้งต่อสัปดาห์	เป็นประจำ 7 ครั้งต่อสัปดาห์ / ทุกวัน
13	ท่านปิดหน้าต่างทุกครั้ง เมื่อมีมลพิษอากาศจากฝุ่นครกหิน ฝุ่นหิน หรือไม่					
14	ท่านหลีกเลี่ยงถนนที่มีมลพิษอากาศทุกครั้ง เมื่อมีมลพิษอากาศจากฝุ่นครกหิน ฝุ่นหิน หรือไม่					

ส่วนที่ 7 อาการของระบบทางเดินหายใจ

1. อาการของระบบทางเดินหายใจในปัจจุบันและความถี่ที่เกิดขึ้นในแต่ละสัปดาห์

อาการ	มีอาการในปัจจุบัน	ไม่มีอาการในปัจจุบัน	ความถี่ที่เกิดอาการในแต่ละสัปดาห์		
			สัปดาห์ละครั้ง	>1 ครั้ง/สัปดาห์	ทุกวัน
1. ไอ					
2. มีเสมหะ					
3. อาการไอร่วมกับมีเสมหะ					
4. หายใจมีเสียงหวีด					
5. หายใจลำบาก/หายใจขัด					
6. เจ็บหรือแน่นหน้าอก					
7. ระคายจมูก					
8. คัดจมูก					
9. ปวดศรีษะ					
10. วิงเวียน					

อาการ	มีอาการ ในปัจจุบัน	ไม่มี อาการ ในปัจจุบัน	ความถี่ที่เกิดอาการในแต่ละสัปดาห์		
			สัปดาห์ละ ครั้ง	>1 ครั้ง/ สัปดาห์	ทุกวัน
11. ระคายเคืองตา					
12. ระคายเคืองผิวหนัง					
13. คันผิวหนัง					
14. อื่นๆ ระบุ ………					

2. ถ้าคำถามไม่ชัดเจนกับอาการของท่าน ให้ตอบ ไม่เข้าข่าย ถ้าไม่แน่ใจที่จะตอบใช่ ให้ตอบว่า ไม่ใช่

2.1 อาการไอ (Cough)

2.1 A. ท่านมักมีอาการไอบ่อยๆ … 1. ใช่ …2. ไม่ใช่

(นับรวม หลังจากการสูบบุหรี่หรือหลังออกจากบ้าน)

ถ้าไม่ใช่ ข้ามไปข้อ 2.1 C

2.1 B. ท่านมีอาการไอมากกว่า 4-6 ครั้งต่อวัน …. 1. ใช่ ... 2. ไม่ใช่

หรือ มากกว่า 4 วันต่อสัปดาห์

2.1 C. ท่านมีอาการไอติดต่อกันเป็นเวลานาน …. 1. ใช่ ... 2. ไม่ใช่

ตอนตื่นนอนในตอนเช้า

2.1 D. ท่านมีอาการไอติดต่อกันเป็นเวลานาน …. 1. ใช่ ... 2. ไม่ใช่

ในขณะพักหรือในเวลากลางคืน

ถ้าไม่ใช่ ข้ามไปข้อ 2.2

2.1 E. ท่านมีอาการไอติดต่อกันตลอดทั้งวัน …. 1. ใช่ ... 2. ไม่ใช่

เป็นเวลาตั้งแต่ 3 เดือนขึ้นไป …. 88. ไม่เข้าข่าย

2.1 F. ท่านมีอาการเหล่านี้ เป็นเวลา …….. ปี …. 88. ไม่เข้าข่าย

2.2 อาการมีเสมหะ (Phlegm)

2.2 A. ท่านมีเสมหะเป็นประจำ …. 1. ใช่ ... 2. ไม่ใช่

(นับรวม หลังจากการสูบบุหรี่หรือหลังออกจากบ้าน)

ถ้าไม่ใช่ ข้ามไปข้อ 2.2 C

2.2 B. ท่านมีเสมหะมากกว่า 2 ครั้งต่อวัน …. 1. ใช่ ... 2. ไม่ใช่

หรือ มากกว่า 4 วันต่อสัปดาห์

2.2 C. ท่านมีเสมหะมากในช่วงเวลาตื่นนอนตอนเช้า.... 1. ใช่ ... 2. ไม่ใช่

2.2 D. ท่านมีเสมหะมากในขณะพักหรือในเวลากลางคืน .... 1. ใช่ ... 2. ไม่ใช่

ถ้าไม่ใช่ ข้ามไปข้อ 2.3

2.2 E. ท่านมีเสมหะบ่อยๆตลอดทั้งวัน.... 1. ใช่ ... 2. ไม่ใช่ .... 8. ไม่เข้าข่าย
เป็นเวลาตั้งแต่ 3 เดือนติดต่อกันขึ้นไป

2.2 F. ท่านมีอาการเหล่านี้ เป็นเวลา ...... ปี .... 88. ไม่เข้าข่าย

2.3 อาการไอร่วมกับมีเสมหะ (Episodes of cough and phlegm)

2.3 A. ท่านมีอาการไอร่วมกับการมีเสมหะเป็นเวลา 3 สัปดาห์ ... 1. ใช่ ... 2. ไม่ใช่
หรือมากกว่า 3 สัปดาห์

ถ้าใช่ ให้ทำข้อ 2.3 B

2.3 B. ท่านมีอาการเหล่านี้ เป็นเวลา ..... ปี .... 88. ไม่เข้าข่าย

2.4 อาการหายใจมีเสียง (Wheezing)

2.4.1 A. ท่านมักจะมีอาการหายใจมีเสียงในเวลาใด

1. ขณะเป็นหวัด .... 1. ใช่ .... 2. ไม่ใช่

2. ช่วงที่อากาศเย็น .... 1. ใช่ .... 2. ไม่ใช่

3. ตลอดทั้งวันหรือทั้งคืน .... 1. ใช่ .... 2. ไม่ใช่

ถ้าใช่ในข้อใดข้อหนึ่ง ให้ทำข้อ 2.4.1 B

2.4.1 B. ท่านมีอาการเหล่านี้ เป็นเวลา ..... ปี ... 88. ไม่เข้าข่าย

7.2.4.2 A. ท่านมักจะมีอาการหายใจมีเสียงจนหายใจไม่ทัน .... 1. ใช่ .... 2. ไม่ใช่
หรือหายใจขัด

ถ้าใช่ ให้ทำข้อ 2.4.2 B, C, D

2.4.2 B. ท่านมีอาการเหล่านี้ เมื่ออายุเท่าไร ..... ปี .... 88. ไม่เข้าข่าย

2.4.2 C. ท่านมีอาการดังกล่าว ร่วมกับอาการอื่นอีก .... 1. ใช่.... 2. ไม่ใช่
.... 88. ไม่เข้าข่าย

2.4.2 D. ท่านเคยได้รับการรักษาอาการของโรคดังกล่าว.... 1. ใช่ .... 2. ไม่ใช่
.... 8. ไม่เข้าข่าย

2.5 อาการหายใจขัด (Breathless)

2.5.1 ท่านมีโรคประจำตัวหรือไม่ ถ้ามีให้ระบุอาการของโรค ....

2.5.2 A. ท่านมีอาการหายใจขัดหรือเหนื่อยง่ายหรือไม่ ขณะที่.... 1. ใช่... 2. ไม่ใช่
ท่านเดินเร็วๆ บนพื้นราบธรรมดาหรือเดินขึ้นที่สูง เพียงเล็กน้อย

ถ้าใช่ ให้ทำข้อ 2.5.2 B, C, D, E

2.5.2 B. ปัจจุบัน ในขณะที่ท่านกำลังเดินอย่างคนธรรมดา... 1. ใช่ .... 2. ไม่ใช่
พร้อมกับคนอื่นๆบนพื้นราบ ท่านรู้สึกว่าเดินช้ากว่าคนอื่น.... 8. ไม่เข้าข่าย

2.5.2 C. ขณะที่ท่านกำลังเดินอยู่บนพื้นราบ .... 1. ใช่ .... 2. ไม่ใช่
ท่านต้องหยุดพักหายใจ .... 8. ไม่เข้าข่าย

2.5.2 D. ขณะที่ท่านกำลังเดินอยู่บนพื้นราบ ในระยะทาง.... 1. ใช่ .... 2. ไม่ใช่
100 เมตร หรือเมื่อประมาณ 2-3 นาทีผ่านไป .... 8. ไม่เข้าข่าย
ท่านต้องหยุด พักหายใจ

2.5.2 E. ท่านรู้สึกหายใจขัด เมื่อกำลังสวมใส่หรือเปลี่ยน.... 1. ใช่ .... 2. ไม่ใช่
เสื้อผ้าหรือ ขณะกำลังออกจากบ้านหรือไม่ .... 8. ไม่เคยเป็นหวัด

2.6 อาการเจ็บหรือแน่นหน้าอก (Chest colds and chest illness)

2.6.1 A. ท่านมักมีอาการแน่นหน้าอกทุกครั้งที่ท่านเป็นหวัด .... 1. ใช่.... 2. ไม่ใช่
.... 8. ไม่เข้าข่าย

2.6.2 A. ในช่วงระยะเวลา 3 ปีที่ผ่านมา ท่านมีอาการแน่นหน้าอก .... 1. ใช่
จนทำให้ท่านต้อง หยุกพักหรือไม่ .... 2. ไม่ใช่
<u>ถ้าใช่ ให้ทำข้อ 2.6.2 B, C</u>

2.6.2 B. ท่านมีเสมหะร่วมกับการเจ็บหน้าอก ... 1. ใช่ ... 2. ไม่ใช่ ... 8. ไม่เข้าข่าย

2.6.2 C. ในช่วงระยะเวลา 3 ปีที่ผ่านมา ท่านเคยมีอาการ จำนวน .... ครั้ง
ไม่สบาย เนื่องจากเสมหะตลอดสัปดาห์หรือมากกว่า ... ไม่เคยไม่สบาย
.... 8. ไม่เข้าข่าย

2.7 ความเจ็บป่วยที่ผ่านมา (ความเจ็บป่วยในอดีต) (Past illness)

2.7.1 ท่านเคยมีปัญหาเกี่ยวกับปอด ก่อนอายุ 16 ปี ... 1. ใช่ .... 2. ไม่ใช่

2.7.2 ท่านมีอาการต่อไปนี้หรือไม่

2.7.2 1A. หลอดลมอักเสบ .... 1. ใช่ .... 2. ไม่ใช่
<u>ถ้าใช่ ให้ทำข้อ 2.7.2 1B, 1C</u>

1B. ท่านได้รับการตรวจจากแพทย์หรือไม่ ... 1. ใช่ .... 2. ไม่ใช่

ส่วนที่ 8 คุณภาพชีวิต

1. สุขภาพทั่วไป (General health)

1.1 โดยทั่วไป ท่านคิดว่า สุขภาพของท่านเป็นอย่างไร ในขณะนี้

..... 1 ดีเลิศ ..... 2 ดีมาก ..... 3 ดี ..... 4 พอใช้ ..... 5 ไม่ดี

1.2 เมื่อเทียบกับปีที่แล้ว ท่านคิดว่า สุขภาพของท่านเป็นอย่างไร

….. 1 ดีกว่า เมื่อปีที่แล้ว ….. 2 ค่อนข้าง ดีกว่าเมื่อปีที่แล้ว

….. 3 เหมือนกับ เมื่อปีที่แล้ว ….. 4 ค่อนข้าง แย่ดีกว่าเมื่อปีที่แล้ว

….. 5 แย่ดีกว่าเมื่อปีที่แล้วมาก

2. ข้อจำกัดของการทำกิจกรรม (Limitations of Activities)

คำถามต่อไปนี้ เป็นคำถามเกี่ยวกับกิจกรรมที่ท่านปฏิบัติในแต่ละวัน ท่านคิดว่า สุขภาพของท่านทำให้ท่านมีปัญหา ในการทำกิจกรรมเหล่านี้หรือไม่ ถ้ามี มีมากหรือมีน้อยเพียงใด (วงกลมหนึ่งคำตอบ ในแต่ละบรรทัด)

ลำดับ	ท่านมีปัญหาเวลาทำสิ่งเหล่านี้มากน้อยเพียงใด	มีปัญหามาก	มีปัญหาเล็กน้อย	ไม่มีปัญหาเลย
1	กิจกรรมที่ต้องใช้แรงมาก เช่น วิ่งไกลๆ ทำงานที่ต้องออกแรงมากๆ ยกของหนัก ออกกำลังกายอย่างหนัก	1	2	3
2	กิจกรรมที่ต้องใช้แรงปานกลาง เช่น เลื่อนโต๊ะ รดน้ำต้นไม้ ขี่จักรยาน 100 เมตร ซักเสื้อผ้าด้วยตนเอง 8-10 ชิ้น	1	2	3
3	เดินยกหรือหิ้วของเต็มสองมือ	1	2	3
4	เดินขึ้นบันไดหลายชั้นติดต่อกัน	1	2	3
5	เดินขึ้นบันไดหนึ่งชั้น	1	2	3
6	งอเข่า คุกเข่า โก้งโค้ง/โน้มตัวลง	1	2	3
7	เดิน มากกว่าหนึ่งกิโลเมตร	1	2	3
8	เดิน มากกว่าครึ่งกิโลเมตร	1	2	3
9	เดิน ประมาณหนึ่งร้อยเมตร	1	2	3
10	อาบน้ำ แต่งตัว	1	2	3

3. ปัญหาสุขภาพทางกาย (Physical health problems)

ในระยะ 1 เดือนที่ผ่านมา สุขภาพกายของท่านทำให้ท่านมีปัญหา เวลาทำงานหรือกิจวัตรประจำวัน หรือไม่

ลำดับ	ท่านมีปัญหาเวลาทำสิ่งเหล่านี้มากน้อยเพียงใด	มี	ไม่มี
1	ทำงานหรือทำกิจกรรมต่างๆ ได้ไม่นานเท่าเดิม	1	2
2	ทำงานได้น้อยกว่าที่ต้องการ	1	2
3	ไม่สามารถทำงานหรือกิจกรรมบางอย่างได้ อย่างที่เคยทำ	1	2
4	มีความยากลำบากในการทำงาน หรือกิจกรรม (เช่น ต้องใช้ความพยายามมากเป็นพิเศษ)	1	2

4. ปัญหาสุขภาพทางอารมณ์ (Emotional health problems)

ในระยะ 1 เดือนที่ผ่านมา อารมณ์ของท่าน (เช่น รู้สึกหดหู่ หรือวิตกกังวล) ทำให้ท่านมีปัญหาในการทำงานหรือกิจกรรมปกติประจำวัน หรือไม่

ลำดับ	ท่านมีปัญหาเวลาทำสิ่งเหล่านี้ มากน้อยเพียงใด	มี	ไม่มี
1	ทำงานหรือทำกิจวัตรประจำวันได้ไม่นานเท่าเดิม	1	2
2	ทำงานได้น้อยกว่าที่ต้องการ	1	2
3	มีความระมัดระวังในการทำงานหรือกิจวัตรประจำวันน้อยกว่าเดิม	1	2

5. กิจกรรมทางสังคม (Social activities)

สุขภาพทางร่างกายหรืออารมณ์ของท่าน มีผลกระทบต่อการทำกิจกรรมทางสังคม เช่น การพบปะสังสรรค์กับครอบครัว ญาติสนิทมิตรสหาย หรือเพื่อนฝูง หรือเพื่อนบ้าน มากน้อยเพียงใด

….. 1 ไม่มีผลเลยจนนิดเดียว ….. 2 มีผลเล็กน้อย ….. 3 มีผลปานกลาง

….. 4 มีผลค่อนข้างมาก ….. 5 มีผลมากที่สุด

6. การเจ็บปวด (Pain)

6.1 ในระยะ 1 เดือนที่ผ่านมา ท่านมีอาการปวดเมื่อยร่างกาย เช่น ปวดหัว ปวดท้อง ปวดเข่า ปวดกล้ามเนื้อ รุนแรงเพียงใด

….. 1 ไม่มีอาการเลย ….. 2 มีอาการเล็กน้อยมาก ….. 3 มีอาการเล็กน้อย

….. 4 มีอาการมาก ….. 5 มีอาการรุนแรงมาก

6.2 ในระยะ 1 เดือนที่ผ่านมา ท่านมีอาการปวดเมื่อยร่างกายของท่าน มีผลกระทบต่อการทำงาน ทั้งงานที่ทำงานและงานบ้าน เช่น ทำความสะอาด ล้างจาน ทำครัว) มากน้อยแค่ไหน

….. 1 ไม่มีผลเลย ….. 2 มีผลเล็กน้อย ….. 3 มีผลปานกลาง

….. 4 มีค่อนข้างมาก ….. 5 มีผลมากที่สุด

7. พลังงานและอารมณ์ (Energy and emotions)

ในระยะ 1 เดือนที่ผ่านมา ท่านเคยมีความรู้สึกต่อไปนี้บ่อยเพียงใด

ลำดับ	ท่านเคยมีความรู้สึกต่อไปนี้บ่อยเพียงใด	ตลอดเวลา	เกือบตลอดเวลา	บ่อยๆ	บางครั้ง	นานๆ ครั้ง	ไม่มีเลย
1	ท่านรู้สึก มีชีวิตชีวา กระปรี้กระเปร่า	1	2	3	4	5	6
2	ท่านรู้สึก วิตกกังวล	1	2	3	4	5	6
3	ท่านรู้สึก หดหู่ เศร้าซึม มากจนไม่มีอะไรทำให้ท่านรู้สึกดีขึ้นได้	1	2	3	4	5	6
4	ท่านรู้สึก อารมณ์เย็นและสงบ	1	2	3	4	5	6
5	ท่านรู้สึก มีพละกำลังมาก	1	2	3	4	5	6
6	ท่านรู้สึก ท้อแท้ และหดหู่ใจ	1	2	3	4	5	6
7	ท่านรู้สึก หมดเรี่ยวแรง	1	2	3	4	5	6
8	ท่านรู้สึก ตัวเองเป็นคนที่มีความสุขคนหนึ่ง	1	2	3	4	5	6
9	ท่านรู้สึก เหนื่อยล้า	1	2	3	4	5	6

8. กิจกรรมทางสังคม (Social activities)

ในระยะ 1 เดือนที่ผ่านมา สุขภาพทางร่างกายหรืออารมณ์ของท่าน มีผลกระทบต่อการทำกิจกรรมทางสังคม เช่น การพบปะสังสรรค์กับครอบครัว ญาติสนิทมิตรสหาย หรือเพื่อนฝูง หรือเพื่อนบ้าน บ่อยแค่ไหน

….. 1 ตลอดเวล ….. 2 เกือบตลอดเวลา ……. 3 บางครั้ง ….. 4 นานๆ ครั้ง ….. 5 ไม่มีเลย

9. สุขภาพทั่วไป (General health)

ข้อความต่อไปนี้ เป็นจริงสำหรับท่านหรือไม่

ลำดับ	ข้อความต่อไปนี้ เป็นจริงสำหรับท่านหรือไม่	จริงแท้แน่นอน	จริง	ไม่รู้	ไม่ค่อยจริง	ไม่จริงแม้แต่น้อย
1	ฉันไม่สบายง่ายกว่าคนอื่นๆ	1	2	3	4	5
2	ฉันมีสุขภาพดี เหมือนกับเพื่อนๆ	1	2	3	4	5
3	ฉันคิดว่า สุขภาพของฉันจะแย่ลง	1	2	3	4	5
4	ฉันคิดว่า สุขภาพของฉันแข็งแรงสมบูรณ์ดีเลิศ	1	2	3	4	5

ขอขอบพระคุณที่ให้ข้อมูล

แบบสอบถาม

เรื่อง การรับรู้ความเสี่ยง พฤติกรรมการป้องกันการสัมผัสฝุ่นซิลิกา และคุณภาพชีวิต ของประชาชนที่อาศัยอยู่โดยรอบพื้นที่ประกอบอาชีพทำครกหิน

คำชี้แจง แบบสัมภาษณ์ประกอบไปด้วย 6 ส่วน ดังนี้

ส่วนที่ 1 ข้อมูลทั่วไป

ส่วนที่ 2 พฤติกรรมสุขภาพ

ส่วนที่ 3 ประวัติการเจ็บป่วย

ส่วนที่ 4 การรับรู้ความเสี่ยงเกี่ยวกับมลพิษอากาศและผลกระทบต่อสุขภาพ

ส่วนที่ 5 พฤติกรรมการป้องกันการสัมผัสฝุ่นซิลิกา

ส่วนที่ 6 คุณภาพชีวิต

ส่วนที่ 1 ข้อมูลทั่วไป

1. วันที่ทำแบบสอบถาม .... (วัน / เดือน / ปี)

2. วันเกิด (วัน / เดือน / ปี) ....

3. หมู่ที่............................

4. อายุ .... ปี

5. เพศ .... ชาย .... หญิง

6. ระดับการศึกษา

.... ประถมศึกษา .... มัธยมศึกษาตอนต้น .... มัธยมศึกษาตอนปลาย

... ปวช. .... ปวส. .... ปริญญาตรี

.... สูงกว่าปริญญาตรี .... อื่นๆ โปรดระบุ ....

7. สถานภาพ

.... โสด ... แต่งงาน .... หย่าร้าง .... แยกกันอยู่

.... อื่นๆ โปรดระบุ ....

8. อาชีพหลัก .... อื่นๆ โปรดระบุ ....

9. ระยะเวลาอาศัยอยู่ในพื้นที่ .... ปี

10. รายได้เฉลี่ยต่อเดือน .... บาท

11. ระยะห่างจากโรงงานผลิตครกหิน .... เมตร UTM ... ค่าความคาดเคลื่อน ... เมตร พิกัด แกน X .... พิกัด แกน Y ....

ส่วนที่ 2 พฤติกรรมสุขภาพ

1. การสูบบุหรี่

1.1 ปัจจุบันท่านสูบบุหรี่หรือไม่ .... 1. ใช่ .... 2. ไม่ใช่

1.2 จำนวนบุหรี่ที่ท่านสูบบุหรี่ในแต่ละวัน ในปัจจุบัน .... มวน/วัน

2. ปัจจุบันท่านดื่มสุราหรือแอลกอฮอล์ .... 1. ใช่ .... 2. ไม่ใช่

ส่วนที่ 3 ประวัติการเจ็บป่วย

1. ท่านเคยได้รับการวินิจฉัยโรคจากแพทย์หรือสถานพยาบาล

ชื่อโรค	ไม่เคย	เคยเป็น (หายแล้ว)	เป็น (ยังไม่ได้รักษา)	เป็น (กำลังรักษา)	ไม่แน่ใจ
1. โรคหลอดลมอักเสบ					
2. โรคถุงลมโป่งพอง					
3. โรคหอบหืด					
4. โรคภูมิแพ้					
5. โรควัณโรคปอด					
6. โรคหัวใจ					
7. โรคความดันโลหิตสูง					
8. โรคจมูกอักเสบจากการแพ้					
9. โรคข้ออักเสบ					
10. โรคเบาหวาน					
11. โรคทางประสาท					
12. โรคแพ้ภูมิตนเอง					
13. โรคหลอดเลือด					
14. โรคปอดอื่นๆ (ปอดอักเสบ / ปอดอุดกั้นเรื้อรัง) ระบุ					
15. โรคมะเร็ง (มะเร็งปอด) ระบุ...					
16. การบาดเจ็บ / ผ่าตัดทรวงอก					
17. โรคอัลไซเมอร์					

ชื่อโรค	ไม่เคย	เคยเป็น (หายแล้ว)	เป็น (ยังไม่ได้รักษา)	เป็น (กำลังรักษา)	ไม่แน่ใจ
18. โรคตับและตับอักเสบ					
19. โรคทางจิต					

2. ท่านมีโรคประจำตัวอื่นๆ .... มี ระบุ .... ไม่มี

3. อาการของระบบทางเดินหายใจ

อาการของระบบทางเดินหายใจในปัจจุบันและความถี่ที่เกิดขึ้นในแต่ละสัปดาห์

อาการ	มีอาการในปัจจุบัน	ไม่มีอาการในปัจจุบัน	**ความถี่ที่เกิดอาการในแต่ละสัปดาห์**		
			สัปดาห์ละครั้ง	>1 ครั้ง/สัปดาห์	ทุกวัน
1. ไอ					
2. มีเสมหะ					
3. อาการไอร่วมกับมีเสมหะ					
4. หายใจมีเสียงหวีด					
5. หายใจลำบาก/หายใจขัด					
6. เจ็บหรือแน่นหน้าอก					
7. ระคายจมูก					
8. คัดจมูก					
9. ปวดศรีษะ					
10. วิงเวียน					
11. ระคายเคืองตา					
12. ระคายเคืองผิวหนัง					
13. คันผิวหนัง					
14. อื่นๆ ระบุ					

ส่วนที่ 4 การรับรู้ความเสี่ยงเกี่ยวกับมลพิษอากาศและผลกระทบต่อสุขภาพจากพื้นที่ประกอบอาชีพทำครกหิน

ลำดับ	**คำถาม**	**ความคิดเห็น** ตลอดสัปดาห์ที่ผ่านมา เนื่องด้วยผลของมลพิษอากาศและผลกระทบต่อสุขภาพ**จากการสัมผัสฝุ่นครกหิน ฝุ่นหิน ฝุ่นซิลิกา** คุณมี			
		ไม่เคย	**บางครั้ง**	**บ่อยครั้ง**	**ตลอดเวลา**
1	ความรู้สึกกังวล จากฝุ่นครกหิน ฝุ่นหิน เกี่ยวกับสุขภาพของท่านหรือไม่				
2	มีตาแดง จากฝุ่นครกหิน ฝุ่นหิน หรือไม่				
3	ทรมานจากการระคายเคืองจมูก จากฝุ่นครกหิน ฝุ่นหิน หรือไม่				
4	มีอาการจาม จากฝุ่นครกหิน ฝุ่นหิน หรือไม่				
5	มีคอแห้ง จากฝุ่นครกหิน ฝุ่นหิน หรือไม่				
6	มีไอ จากฝุ่นครกหิน ฝุ่นหิน หรือไม่				
7	มีหายใจลำบาก จากฝุ่นครกหิน ฝุ่นหิน หรือไม่				
8	ทรมานจากอาการปวดหัว จากฝุ่นครกหิน ฝุ่นหิน หรือไม่				
9	มีการเปลี่ยนกิจกรรมยามว่าง จากฝุ่นครกหิน ฝุ่นหิน หรือไม่ (เช่น ออกไปเดินเล่น หรือออกกำลังกาย เป็นต้น)				
10	อยู่ในบ้าน ได้รับผลของมลพิษอากาศ จากฝุ่นครกหิน ฝุ่นหิน หรือไม่				

ลำดับ	คำถาม	ความคิดเห็น ตลอดสัปดาห์ที่ผ่านมา เนื่องด้วยผลของมลพิษอากาศและผลกระทบต่อสุขภาพ**จากการสัมผัสฝุ่นครกหิน ฝุ่นหิน ฝุ่นซิลิกา** คุณมี			
		ไม่เคย	**บางครั้ง**	**บ่อยครั้ง**	**ตลอดเวลา**
11	อากาศที่บ้าน ได้รับผลของมลพิษอากาศ จากฝุ่นครกหิน ฝุ่นหิน หรือไม่				
12	มีการปิดประตูหน้าต่างในบ้าน จากฝุ่นครกหิน ฝุ่นหิน หรือไม่				
13	ใช้เครื่องฟอกอากาศให้สดชื่นในบ้าน จากฝุ่นครกหิน ฝุ่นหิน หรือไม่				
14	หลีกเลี่ยงการเปิดหน้าต่างของท่าน จากฝุ่นครกหิน ฝุ่นหิน หรือไม่				
15	รู้สึกว่า ต้องล้างมือหรือใบหน้า จากฝุ่นครกหิน ฝุ่นหิน หรือไม่				
16	ดื่มน้ำมากขึ้นกว่าปกติ จากฝุ่นครกหิน ฝุ่นหิน หรือไม่				
17	มีกลิ่นที่ไม่พึงประสงค์ หรือกลิ่นจากภายนอกบ้าน จากฝุ่นครกหิน ฝุ่นหิน หรือไม่				
18	มีกลิ่นที่ไม่พึงประสงค์ หรือกลิ่นจากภายในบ้าน จากฝุ่นครกหิน ฝุ่นหิน หรือไม่				
19	สังเกตเห็นผ้าม่านของท่านเปื้อน จากฝุ่นครกหิน ฝุ่นหิน หรือไม่				
20	สังเกตเห็นว่าท้องฟ้ามืดมัว ด้วยมลพิษอากาศ จากฝุ่นครกหิน ฝุ่นหิน หรือไม่				

ลำดับ	คำถาม	**ความคิดเห็น** ตลอดสัปดาห์ที่ผ่านมา เนื่องด้วยผลของมลพิษอากาศและผลกระทบต่อสุขภาพ**จากการสัมผัสฝุ่นครกหิน ฝุ่นหิน ฝุ่นซิลิกา** คุณมี			
		ไม่เคย	**บางครั้ง**	**บ่อยครั้ง**	**ตลอดเวลา**
21	คุณภาพชีวิตของท่านลดลง จากฝุ่นครกหิน ฝุ่นหิน หรือไม่				
22	คิดเกี่ยวกับการย้ายบ้าน จากฝุ่นครกหิน ฝุ่นหิน หรือไม่				

ส่วนที่ 5 พฤติกรรมการป้องกันการสัมผัสจากฝุ่นครกหิน ฝุ่นหิน ฝุ่นซิลิกา

ลำดับ	คำถาม	คำตอบ				
		ไม่เคย 0 ครั้งต่อสัปดาห์	เป็นครั้งคราว 1-2 ครั้งต่อสัปดาห์	บางครั้ง 3-4 ครั้งต่อสัปดาห์	บ่อย 5-6 ครั้งต่อสัปดาห์	เป็นประจำ 7 ครั้งต่อสัปดาห์ / ทุกวัน
1	ท่านเดินหนีทุกครั้ง เมื่อมีมลพิษอากาศจากฝุ่นครกหิน ฝุ่นหิน หรือไม่					
2	ท่านสวมหน้ากากทุกครั้ง เมื่อมีมลพิษอากาศจากฝุ่นครกหิน ฝุ่นหิน หรือไม่					
3	ท่านแขวนผ้าทุกครั้ง เมื่อมีมลพิษอากาศจากฝุ่นครกหิน ฝุ่นหิน หรือไม่					

ลำดับ	คำถาม	คำตอบ				
		ไม่เคย 0 ครั้งต่อสัปดาห์	เป็นครั้งคราว 1-2 ครั้งต่อสัปดาห์	บางครั้ง 3-4 ครั้งต่อสัปดาห์	บ่อย 5-6 ครั้งต่อสัปดาห์	เป็นประจำ 7 ครั้งต่อสัปดาห์ / ทุกวัน
4	ท่านสวมอุปกรณ์ป้องกันอันตรายส่วนบุคคล (PPE) ตามคำแนะนำหรือขั้นตอนที่ถูกต้องทุกครั้ง เมื่อมีมลพิษอากาศจากฝุ่นครกหิน ฝุ่นหิน หรือไม่					
5	ท่านสวมใส่หน้ากากป้องกันฝุ่นชนิด N95 เมื่อมีมลพิษอากาศจากฝุ่นครกหิน ฝุ่นหิน หรือไม่					
6	ท่านสวมใส่อุปกรณ์ป้องกันอันตรายส่วนบุคคล (PPE) ตลอดเวลาทำงาน เมื่อมีมลพิษอากาศจากฝุ่นครกหิน ฝุ่นหิน หรือไม่หรือไม่					
7	เมื่อท่านไม่ได้ใช้อุปกรณ์ป้องกันอันตรายส่วนบุคคล (PPE) ท่านเก็บไว้ในที่แห้ง สะอาด ไม่มีมลพิษอากาศจากฝุ่นครกหิน ฝุ่นหิน หรือไม่					
8	ท่านร้องเรียนปัญหาทุกครั้ง เมื่อมีมลพิษอากาศจากฝุ่นครกหิน ฝุ่นหิน หรือไม่					

ลำดับ	คำถาม	คำตอบ				
		ไม่เคย 0 ครั้งต่อสัปดาห์	เป็นครั้งคราว 1-2 ครั้งต่อสัปดาห์	บางครั้ง 3-4 ครั้งต่อสัปดาห์	บ่อย 5-6 ครั้งต่อสัปดาห์	เป็นประจำ 7 ครั้งต่อสัปดาห์ / ทุกวัน
9	ท่านมีความรู้เพียงพอต่อการป้องกันตนเองทุกครั้ง เมื่อมีมลพิษอากาศจากฝุ่นครกหิน ฝุ่นหิน หรือไม่					
10	ท่านได้รับความรู้จากหน่วยงานภายนอกต่อการป้องกันตนเองทุกครั้ง เมื่อมีมลพิษอากาศจากฝุ่นครกหิน ฝุ่นหิน หรือไม่					
11	ท่านดื่มน้ำ ในพื้นที่ที่มีมลพิษอากาศจากฝุ่นครกหิน ฝุ่นหิน หรือไม่					
12	ท่านรับประทานอาหารหรือขนมในพื้นที่ที่มีมลพิษอากาศจากฝุ่นครกหิน ฝุ่นหิน หรือไม่					
13	ท่านปิดหน้าต่างทุกครั้ง เมื่อมีมลพิษอากาศจากฝุ่นครกหิน ฝุ่นหิน หรือไม่					
14	ท่านหลีกเลี่ยงถนนที่มีมลพิษอากาศทุกครั้ง เมื่อมีมลพิษอากาศจากฝุ่นครกหิน ฝุ่นหิน หรือไม่					

ส่วนที่ 6 คุณภาพชีวิต

1. สุขภาพทั่วไป (General health)

1.1 โดยทั่วไป ท่านคิดว่า สุขภาพของท่านเป็นอย่างไร ในขณะนี้

….. 1 ดีเลิศ ….. 2 ดีมาก ….. 3 ดี ….. 4 พอใช้ ….. 5 ไม่ดี

1.2 เมื่อเทียบกับปีที่แล้ว ท่านคิดว่า สุขภาพของท่านเป็นอย่างไร

….. 1 ดีกว่า เมื่อปีที่แล้ว ….. 2 ค่อนข้าง ดีกว่าเมื่อปีที่แล้ว

….. 3 เหมือนกับ เมื่อปีที่แล้ว ….. 4 ค่อนข้าง แย่ดีกว่าเมื่อปีที่แล้ว

….. 5 แย่ดีกว่าเมื่อปีที่แล้วมาก

2. ข้อจำกัดของการทำกิจกรรม (Limitations of Activities)

คำถามต่อไปนี้ เป็นคำถามเกี่ยวกับกิจกรรมที่ท่านปฏิบัติในแต่ละวัน ท่านคิดว่า สุขภาพของท่านทำให้ท่านมีปัญหา ในการทำกิจกรรมเหล่านี้หรือไม่ ถ้ามี มีมากหรือมีน้อยเพียงใด (วงกลมหนึ่งคำตอบ ในแต่ละบรรทัด)

ลำดับ	**ท่านมีปัญหาเวลาทำสิ่งเหล่านี้มากน้อยเพียงใด**	**มีปัญหามาก**	**มีปัญหาเล็กน้อย**	**ไม่มีปัญหาเลย**
1	กิจกรรมที่ต้องใช้แรงมาก เช่น วิ่งไกลๆ ทำงานที่ต้องออกแรงมากๆ ยกของหนัก ออกกำลังกายอย่างหนัก	1	2	3
2	กิจกรรมที่ต้องใช้แรงปานกลาง เช่น เลื่อนโต๊ะ รดน้ำต้นไม้ ขี่จักรยาน 100 เมตร ซักเสื้อผ้าด้วยตนเอง 8-10 ชิ้น	1	2	3
3	เดินยกหรือหิ้วของเต็มสองมือ	1	2	3
4	เดินขึ้นบันไดหลายชั้นติดต่อกัน	1	2	3
5	เดินขึ้นบันไดหนึ่งชั้น	1	2	3
6	งอเข่า คุกเข่า โก้งโค้ง/โน้มตัวลง	1	2	3
7	เดิน มากกว่าหนึ่งกิโลเมตร	1	2	3
8	เดิน มากกว่าครึ่งกิโลเมตร	1	2	3
9	เดิน ประมาณหนึ่งร้อยเมตร	1	2	3
10	อาบน้ำ แต่งตัว	1	2	3

3. ปัญหาสุขภาพทางกาย (Physical health problems)

ในระยะ 1 เดือนที่ผ่านมา สุขภาพกายของท่านทำให้ท่านมีปัญหา เวลาทำงานหรือกิจวัตรประจำวัน หรือไม่

ลำดับ	ท่านมีปัญหาเวลาทำสิ่งเหล่านี้มากน้อยเพียงใด	มี	ไม่มี
1	ทำงานหรือทำกิจกรรมต่างๆ ได้ไม่นานเท่าเดิม	1	2
2	ทำงานได้น้อยกว่าที่ต้องการ	1	2
3	ไม่สามารถทำงานหรือกิจกรรมบางอย่างได้ อย่างที่เคยทำ	1	2
4	มีความยากลำบากในการทำงาน หรือกิจกรรม (เช่น ต้องใช้ความพยายามมากเป็นพิเศษ)	1	2

4. ปัญหาสุขภาพทางอารมณ์ (Emotional health problems)

ในระยะ 1 เดือนที่ผ่านมา อารมณ์ของท่าน (เช่น รู้สึกหดหู่ หรือวิตกกังวล) ทำให้ท่านมีปัญหาในการทำงานหรือกิจกรรมปกติประจำวัน หรือไม่

ลำดับ	ท่านมีปัญหาเวลาทำสิ่งเหล่านี้ มากน้อยเพียงใด	มี	ไม่มี
1	ทำงานหรือทำกิจวัตรประจำวันได้ไม่นานเท่าเดิม	1	2
2	ทำงานได้น้อยกว่าที่ต้องการ	1	2
3	มีความระมัดระวังในการทำงานหรือกิจวัตรประจำวันน้อยกว่าเดิม	1	2

5. กิจกรรมทางสังคม (Social activities)

สุขภาพทางร่างกายหรืออารมณ์ของท่าน มีผลกระทบต่อการทำกิจกรรมทางสังคม เช่น การพบปะสังสรรค์กับครอบครัว ญาติสนิทมิตรสหาย หรือเพื่อนฝูง หรือเพื่อนบ้าน มากน้อยเพียงใด

….. 1 ไม่มีผลเลยจนนิดเดียว ….. 2 มีผลเล็กน้อย ….. 3 มีผลปานกลาง

….. 4 มีผลค่อนข้างมาก ….. 5 มีผลมากที่สุด

6. การเจ็บปวด (Pain)

6.1 ในระยะ 1 เดือนที่ผ่านมา ท่านมีอาการปวดเมื่อยร่างกาย เช่น ปวดหัว ปวดท้อง ปวดเข่า ปวดกล้ามเนื้อ รุนแรงเพียงใด

….. 1 ไม่มีอาการเลย ….. 2 มีอาการเล็กน้อยมาก ….. 3 มีอาการเล็กน้อย

….. 4 มีอาการมาก ….. 5 มีอาการรุนแรงมาก

6.2 ในระยะ 1 เดือนที่ผ่านมา ท่านมีอาการปวดเมื่อยร่างกายของท่าน มีผลกระทบต่อการทำงาน ทั้งงานที่ทำงานและงานบ้าน เช่น ทำความสะอาด ล้างจาน ทำครัว) มากน้อยแค่ไหน

….. 1 ไม่มีผลเลย ….. 2 มีผลเล็กน้อย ….. 3 มีผลปานกลาง

….. 4 มีค่อนข้างมาก ….. 5 มีผลมากที่สุด

7. พลังงานและอารมณ์ (Energy and emotions)

ในระยะ 1 เดือนที่ผ่านมา ท่านเคยมีความรู้สึกต่อไปนี้บ่อยเพียงใด

ลำดับ	ท่านเคยมีความรู้สึกต่อไปนี้บ่อยเพียงใด	ตลอดเวลา	เกือบตลอดเวลา	บ่อยๆ	บางครั้ง	นานๆ ครั้ง	ไม่มีเลย
1	ท่านรู้สึก มีชีวิตชีวา กระปรี้กระเปร่า	1	2	3	4	5	6
2	ท่านรู้สึก วิตกกังวล	1	2	3	4	5	6
3	ท่านรู้สึก หดหู่ เศร้าซึม มากจนไม่มีอะไรทำให้ท่านรู้สึกดีขึ้นได้	1	2	3	4	5	6
4	ท่านรู้สึก อารมณ์เย็นและสงบ	1	2	3	4	5	6
5	ท่านรู้สึก มีพละกำลังมาก	1	2	3	4	5	6
6	ท่านรู้สึก ท้อแท้ และหดหู่ใจ	1	2	3	4	5	6
7	ท่านรู้สึก หมดเรี่ยวแรง	1	2	3	4	5	6
8	ท่านรู้สึก ตัวเองเป็นคนที่มีความสุขคนหนึ่ง	1	2	3	4	5	6
9	ท่านรู้สึก เหนื่อยล้า	1	2	3	4	5	6

8. กิจกรรมทางสังคม (Social activities)

ในระยะ 1 เดือนที่ผ่านมา สุขภาพทางร่างกายหรืออารมณ์ของท่าน มีผลกระทบต่อการทำกิจกรรมทางสังคม เช่น การพบปะสังสรรค์กับครอบครัว ญาติสนิทมิตรสหาย หรือเพื่อนฝูง หรือเพื่อนบ้าน บ่อยแค่ไหน

….. 1 ตลอดเวลา ….. 2 เกือบตลอดเวลา …. 3 บางครั้ง ….. 4 นานๆ ครั้ง ….. 5 ไม่มีเลย

9. สุขภาพทั่วไป (General health)

ข้อความต่อไปนี้ เป็นจริงสำหรับท่านหรือไม่

ลำดับ	ข้อความต่อไปนี้ เป็นจริงสำหรับท่านหรือไม่	จริงแท้แน่นอน	จริง	ไม่รู้	ไม่ค่อยจริง	ไม่จริงแม้แต่น้อย
1	ฉันไม่สบายง่ายกว่าคนอื่นๆ	1	2	3	4	5
2	ฉันมีสุขภาพดี เหมือนกับเพื่อนๆ	1	2	3	4	5
3	ฉันคิดว่า สุขภาพของฉันจะแย่ลง	1	2	3	4	5
4	ฉันคิดว่า สุขภาพของฉันแข็งแรงสมบูรณ์ดีเลิศ	1	2	3	4	5

ขอขอบพระคุณที่ให้ข้อมูล

APPENDIX B

Preventive behaviors of crystalline silica exposure among SMW
and people living around stone-mortar factories

Table 1 Preventive behaviors of crystalline silica exposure among SMW

Behaviors	Answer, n (%)				
	Never	Occasionally	Sometimes	Often	Always
Wearing PPE when exposed air pollution					
1. You wear mask, when you exposed air pollution from stone-mortar dust.	6 (10.5)	1 (1.8)	12 (21.1)	11 (19.3)	27 (47.4)
2. You hang cloths, when you exposed air pollution from stone-mortar dust.	5 (8.8)	4 (7.0)	9 (15.8)	5 (8.8)	34 (59.6)
3. You wear PPE and follow-up procedures, when you exposed air pollution from stone-mortar dust.	14 (24.6)	7 (12.3)	9 (15.8)	12 (21.1)	15 (26.3)
4. You wear N95 mask, when you exposed air pollution from stone-mortar dust.	38 (66.7)	3 (5.3)	5 (8.8)	2 (3.5)	9 (15.8)

Table 1 (Continued)

Behaviors	Answer, n (%)				
	Never	Occasionally	Sometimes	Often	Always
5. You wear PPE all times in working time, when you exposed air pollution from stone-mortar dust.	19 (33.3)	4 (7.0)	8 (14.0)	9 (15.8)	17 (29.8)
6. You keep PPE in clean, when you do not expose to air pollution from stone-mortar dust.	15 (26.3)	6 (10.5)	5 (8.8)	13 (22.8)	18 (31.6)
Knowledge					
7. You walk away, when you exposed air pollution from stone-mortar dust.	13 (22.8)	15 (26.3)	9 15.8	14 (24.6)	6 (10.5)
8. You have complaint, when you exposed air pollution from stone-mortar dust.	49 (86.0)	6 (10.5)	2 (3.5)	0 (0.0)	0 (0.0)
9. You have knowledge to self-prevention, when you exposed air pollution from stone-mortar dust.	2 (3.5)	15 (26.3)	14 (24.6)	15 (26.3)	11 (19.3)

Table 1 (Continued)

Behaviors	Answer, n (%)				
	Never	**Occasionally**	**Sometimes**	**Often**	**Always**
10. You get knowledge to self-prevention from outsource, when you exposed air pollution from stone-mortar dust.	35 (61.4)	8 (14.0)	8 (14.0)	2 (3.5)	4 (7.0)
Environmental management					
11. You drink water at workplace of stone-mortar area.	17 (29.8)	9 (15.8)	8 (14.0)	6 (10.5)	17 (29.8)
12. You take food at workplace of stone-mortar area.	8 (14.0)	4 (7.0)	5 (8.8)	7 (12.3)	33 (57.9)
13. You open window, when you exposed air pollution from stone-mortar dust.	36 (63.2)	5 (8.8)	4 (7.0)	3 (5.3)	9 (15.8)
14. You avoid road, when you exposed air pollution from stone-mortar dust.	20 (35.1)	13 (22.8)	12 (21.1)	6 (10.5)	6 (10.5)

Table 2 Preventive behavior among people living around stone-mortar factories

Behaviors	Answer, n (%)				
	Never	**Occasionally**	**Sometimes**	**Often**	**Always**
Wearing PPE when exposed air pollution					
1. You wear mask, when you exposed air pollution from stone-mortar dust.	123 (37.8)	51 (15.7)	74 (22.8)	30 (9.2)	47 (14.5)
2. You hang cloths, when you exposed air pollution from stone-mortar dust.	14 (4.3)	19 (5.8)	61 (18.8)	59 (18.2)	172 (52.9)
3. You wear PPE and follow-up procedures, when you exposed air pollution from stone-mortar dust.	182 (56.0)	43 (13.2)	39 (12.0)	29 (8.9)	32 (9.8)
4. You wear N95 mask, when you exposed air pollution from stone-mortar dust.	261 (80.3)	26 (8.0)	15 (4.6)	7 (2.2)	16 (4.9)
5. You wear PPE all times in working time, when you exposed air pollution from stone-mortar dust.	210 (64.6)	31 (9.5)	30 (9.2)	20 (6.2)	34 (10.5)

Table 2 (Continued)

Behaviors	Answer, n (%)				
	Never	Occasionally	Sometimes	Often	Always
6. You keep PPE in clean, when you do not expose to air pollution from stone-mortar dust.	201 (61.8)	32 (9.8)	25 (7.7)	26 (8.0)	41 (12.6)
Knowledge					
7. You walk away, when you exposed air pollution from stone-mortar dust.	61 (18.8)	79 (24.3)	68 (20.9)	60 (18.5)	57 (17.5)
8. You have complaint, when you exposed air pollution from stone-mortar dust.	276 (84.9)	28 (8.6)	11 (3.4)	4 (1.2)	6 (1.8)
9. You have knowledge to self-prevention, when you exposed air pollution from stone-mortar dust.	72 (22.2)	102 ((31.4)	84 (25.8)	33 (10.2)	34 (10.5)
10. You get knowledge to self-prevention from outsource, when you exposed air pollution from stone-mortar dust.	125 (38.5)	82 (25.2)	66 (20.3)	37 (11.4)	15 (4.6)

Table 2 (Continued)

Behaviors	Answer, n (%)				
	Never	Occasionally	Sometimes	Often	Always
Environmental management					
11. You drink water at workplace of stone-mortar area.	10 (3.1)	12 (3.7)	33 (10.2)	47 (14.5)	223 (68.6)
12. You take food at workplace of stone-mortar area.	7 (2.2)	8 (2.5)	28 (8.6)	54 (16.6)	228 (70.2)
13. You open window, when you exposed air pollution from stone-mortar dust.	192 (59.1)	33 (10.2)	34 (10.5)	24 (7.4)	42 (12.9)
14. You avoid road, when you exposed air pollution from stone-mortar dust.	92 (28.3)	64 (19.7)	79 (24.3)	33 (10.2)	57 (17.5)

APPENDIX C

PUBLICATIONS

EFFECTS OF HIGH SILICA EXPOSURE ON RESPIRATORY DISORDERS AMONG STONE-MORTAR WORKERS IN NORTHERN THAILAND

Sakesun Thongtip[1], Penprapa Siviroj[1], Athavudh Deesomchok[2], Tippawan Prapamontol[3], Anawat Wisetborisut[4] and Supakit Khacha-ananda[5]

[1]Department of Community Medicine, Faculty of Medicine, [2]Department of Internal Medicine, Faculty of Medicine, [3]Research Institute for Health Sciences, [4]Department of Family Medicine, Faculty of Medicine, [5]Department of Forensic Medicine, Faculty of Medicine, Chiang Mai University, Chiang Mai, Thailand

Abstract. Particulate matter less than ten micrometers in diameter (PM_{10}) containing crystalline silica if inhaled can cause respiratory symptoms. We aimed to determine exposure levels of Thai stone-mortar workers to PM_{10} containing crystalline silica and its potential link to respiratory disorders. This cross-sectional study was conducted among all available workers who had worked at stone-mortar factories for at least one year in the study area. Subjects were divided into two groups: stone cutters (n=29) and stone grinders (n=28). We had a control group which consisted of 20 age and sex matched agricultural workers. All subjects were aged ≥18 years. We measured the exposure levels to PM_{10} containing crystalline silica using a filter-based gravimetric method. We obtained a history of respiratory symptoms from each subject using the American Thoracic Society Division of Lung Disease questionnaire (ATS-DLD-78A). We checked the respiratory effect of exposure using a lung function test and by performing chest radiographs. We used the chi-square, Fisher's exact and Kruskal-Wallis tests and multiple linear regression analysis to examine associations between selected variables and respiratory disorders. The mean crystalline silica levels found among stone cutter subjects (mean±SD, 0.096±0.094 mg/m^3) and stone grinder subjects (mean±SD, 0.130±0.106 mg/m^3) were significantly greater (p<0.001) than those found in controls (mean±SD, 0.004±0.005 mg/m^3). The numbers of subjects with abnormal chest radiographs and abnormal FEV_1/FVC ratios in the exposed groups were significantly higher than the abnormal numbers found in controls. Three cases of silicosis were diagnosis among stone cutters and grinders but none among controls. The crystalline silica levels found in the studied stone cutters and grinders were negatively associated with the percent predicted levels for FEV_1 (p=0.002), FVC (p=0.011), and FEV_1/FVC (p=0.002). Our findings show PM_{10} containing crystalline silica exposure is associated with respiratory disorders and lung function impairment among studied stone-mortar workers. Stone cutters and grinders in the study area should be monitored for the presence of silica exposure and silicosis. Personal protective equipment should be available and mandatory for these high risk groups in the study area.

Correspondence: Penprapa Siviroj, Faculty of Medicine, Chiang Mai University, 110 Inthavaroros Road, Sriphum Sub-District, Mueang Chiang Mai District, Chiang Mai 50200, Thailand.
Tel: +66 (0) 53 935472; Fax: +66 (0) 53 935476; E-mail: psiviroj@gmail.com

Vol 50 No. 2 March 2019 401

Keywords: crystalline silica, respiratory symptoms, lung function, silicosis, stone-mortar workers

EnvironmentAsia

The International journal published by the Thai Society of Higher Education Institutues on Environment

Date: July 5th, 2019

Dear Penprapa Siviroj

Thank you very much for submitting the manuscript entitled **"Association of health-related quality of life with residential distance from home stone-mortar factories in Northern Thailand" by Sakesun Thongtip, Penprapa Siviroj, Athavudh Deesomchok, Anawat Wisetborisut and Tippawan Prapamontol** TSHE journal, ***EnvironmentAsia.***

I am very pleased to inform you that the manuscript has been accepted to be published in the ***EnvironmentAsia*** Vol. 12 No.3 (September 2019) by two independent referees.

Thank you for considering ***EnvironmentAsia*** for the publication of your research.

Sincerely yours,

Professor Dr. WanidaJinsart,
Editor-in-chief
EnvironmentAsia

http://tshe.org/ea/index.html

CURRICURUM VITAE

Author's Name	Mr. Sakesun Thongtip
Date/Year of Birth	Jan 22, 1979
Place of Birth	Phare Province, Thailand

Education

2002	Bachelor of Science (Public health) Occupational health and safety, Mahidol University, Bangkok, Thailand
2006	Master of Engineering (Safety engineering), Kasetsart University, Bangkok, Thailand
2008	Master of Public Health (Industrail environmental management), Sukhothai Thammathirat Open University, Nonthaburi, Thailand

Scholarship

Graduate study support

Source	Faculty of Medicine
Year	2016

Working experience

2002-2004	Ass't Engineer Tuntex (Thailand) PCL., Map Ta Phut Industrial Estate, Rayong Province, Thailand
2004-2005	Safety Engineer Siam Tyre Phra Pradaeng Co., Ltd., Samutprakran Province, Thailand
2005-2006	Sr. Safety Officer Thai Samsung Electronics Co., Ltd., Sahaphat Group Industrial Estate, Chonburi Province, Thailand
2006-2009	Safety & Environmental Officer/SH&E MR Emission Control Technologies (Thailand) Co., Ltd., Eastern Seaboard Industrial Estate, Rayong Province, Thailand

2009-2009	HSE Specialist Gates Unitta (Thailand) Co., Ltd., Eastern Seaboard Industrial Estate, Rayong Province, Thailand
2009-2010	Lecturer in Public health, Faculty of Public Health, Phitsanulok University, Phitsanulok Province, Thailand
2010-Present	Lecturer in Occupational Health and Safety, Shool of Medicine, University of Phayao, Phayao Province, Thailand

Academic publications

September 2017	Oral presentation in "International Conference on "Health Challenges in Sustainable Development Goals". Title is "Crystalline silica dust exposure and health impact among stone-mortar workers in Phayao Province, Thailand". Faculty of Public Health, Khon Kaen University. (Best outstanding award).
November 2017	Oral presentation in "International conference on regional haze and climate change management". Title is "Respiratory symptoms and quality of life among stone-mortar workers in Phayao Province, Thailand". The Kantary Hill, Chiang mai, Thailand.
March 2019	Sakesun thongtip, Penprapa siviroj, Athavudh deesomchok, Tippawan prapamontol, Anawat wisetborisut, Supakit khacha-ananda. Effect of high silica exposure on respiratory disorders among stone-mortar workers in Northern Thailand. the Southeast Asian Journal of Tropical Medicine and Public Health. 2019; 50(2).
March 2019	Ratana Sapbamrer, Sakesun Thongtip, Supakit Khacha-ananda, Nalin Sittitoon, Klintean Wunnapuk. Changes in lung function and respiratory symptoms during pesticide spraying season among male sprayers. Archives of Environmental and Occupational Health. 2019; 1-10.

September 2019 Sakesun thongtip, Penprapa siviroj, Athavudh deesomchok, Anawat wisetborisut, Tippawan prapamontol. Association of health-related quality of life with residential distance from home stone-mortar factories in Northern Thailand. EnvironmentAsia Journal. 2019; 12 (3).