Factors Associated with Preventive Health Behaviors Regarding Dust Exposure of Workers in Stone Crushing Mills in Saraburi, Thailand

Kamonwan Samana[*] *Arroon Ketsakorn*[**]

ABSTRACT

The purpose of this cross-sectional study was to assess factors relating to the preventive health behaviors regarding dust exposure among 302 workers of 26 stone-crushing mills. A study was conducted from March to August, 2018. Data were collected using questionnaires developed by the researcher along with respirable dust sampling in the working area. Pearson's correlation and regression analysis were used to analyze data. The findings revealed 16 factors significantly associated with preventive health behaviors due to dust exposure of workers ($P<0.05$). The 7 influencing variables included history of smoking, physical activity, working hours daily, perceived susceptibility, perceived barriers, enabling factors and respirable dust concentration in the working area as tested using regression analysis. A regression model was run to predict the preventive health behaviors regarding dust exposure of workers from the 7 variables. These variables could significantly predict the preventive health behaviors regarding dust exposure of workers totaled 44.7% ($R^2=0.447$). Therefore, efforts should be made to manage those variables by designing appropriate activities to reduce undesirable health behaviors of dust exposure.

Keywords: preventive health behaviors, respirable dust, stone-crushing mills, workers, dust exposure

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Correspondence: Arroon Ketsakorn. Faculty of Public Health, Thammasat University, Pathum Thani, 12121, THAILAND. Email: arroon.k@fph.tu.ac.th

[*] The Office of Disease Prevention and Control 4 Saraburi

[**] Faculty of Public Health, Thammasat University

Introduction

The construction stone industry is an essential business to develop and support the economic growth of the country. In 2018, Thailand had 371 stone crushing mill plants distributed throughout the country[1]. Most are located in the Na Phra Lan Pollution Control Zone, Chaloem Phra Kiat District in Saraburi Province. A total of 26 stone crushing mills in the pollution control zone employ around 320 workers[2]. The production process in the stone crushing mill brings large stones through a grinder to reduce them in accordance with customer requirements. The major sources of dust from the stone crushing mill process are the crusher, stone hopper and conveyor belt[3]. These workers are at risk for exposure to mineral dusts that are known to cause pneumoconiosis including asbestos, silica (rock and sand dust) and coal dust. Typically, exposure levels have to be quite high over a long period of time, most often 10 to 30 years, for a worker to develop pneumoconiosis. Quite typically, a long latency period is observed between the first exposure to the dust and the onset of the actual pneumoconiosis disease[4,5]. Pneumoconiosis, due to other dust containing silica, was reported by the Thai Ministry of Public Health totaled 236 patients from 25 provinces (rate 0.39/100,000 population)[6]. As mentioned above, the rate of illness seems to be low, but the severity of the disease is very high. Promoting and supporting preventive health behavior is essential to achieve a sustainable safety culture in the workplace[7, 8]. Research published in recent years specify that the influence of factors on the behavior of dust protection in the workplace comprised work experience, smoking, access to respiratory protection equipment, occupational safety and health policy affecting the dust prevention behavior. These factors could predict the preventive health behaviors regarding dust exposure of workers[9, 10, 11.] However, most research focused only on the relationship between intrinsic and extrinsic factors based on the principle of behavioral science. Consequently, this research aimed to study the factors associated with preventive health behaviors regarding dust exposure of workers in the stone crushing mill. Those included demographics, predisposing, enabling and reinforcing factors and respirable dust concentration in working area, which can affect behavior and lifestyle. The results of this study are expected to play an important role as a support tool in the public health field to reduce unsafe behaviors of workers.

These factors were investigated in terms of the PRECEDE-PROCEED model. Two phases could affect preventive health behaviors, while phase 3 involved behavioral and environmental diagnoses. Factors were causally associated with the preventive health

behaviors regarding dust exposure of workers. First, behavioral and second, environmental factors were considered potential factors, and behavioral and environmental objectives were developed for each potential factor. For behavioral diagnosis, the main potential factors and behavioral objectives were identified for workers in the stone crushing mills. Four main potential behavior factors were identified: mask wearing, workplace cleaning, personal hygiene and health examination. Four behavior objectives were formulated to be preventive health behaviors regarding dust exposure of workers. For environmental diagnosis, environmental objectives were identified for the five Similar Exposure Groups (SEGs) of personal air sampling in each working area. During phase 4 educational and organizational diagnoses were made to examine multiple factors contributing to each of the behavioral and environmental potential factors identified in phase 3. These contributing factors were classified as predisposing, enabling and reinforcing factors. The predisposing factors are antecedents to behavior that provide motivation for actions. They include knowledge, attitudes, beliefs and perceived needs and abilities, including self-efficacy. Enabling factors are regarded as conditions of the environment that facilitate the performance of action by individuals or organizations. They make it possible for motivation to be realized; that is, they enable people to act on their predispositions. These include availability, accessibility, affordability of resources, supportive policies as well as new skills that are needed for behavioral or environmental changes. The reinforcing factors provide rewards or incentives for the continuation of behaviors. Social support, peer influence, and influences from other significant people are all reinforcing factors. They also include social benefits, physical benefits, tangible or imagined rewards and mass media promotions.

Methods

Study design and setting

A cross-sectional study was conducted from March to August 2018. Data was collected from 302 workers from the production process working in the 26 stone crushing mills in the pollution control zone regarding preventive health behaviors regarding dust exposure using the questionnaires developed by researcher. Before collecting the data, these workers were trained to understand the questionnaire by the researcher to ensure that the information received was the most accurate. Another 18 workers refused to participate in the study. In addition, 280 respirable dust samples were taken in the workplace from the 26 stone crushing mills. Personal air sampling points in each of the processes were designed according to their

work position and followed the NIOSH 0600 Method[12]. Criteria of selection of sampling points are presented in Figure 1. Similar Exposure Groups (SEGs) were used to identify group of workers experiencing the same general exposure to risks. Stone crushing mills should establish and use their own SEGs based on observation and sampling of their specific work groups. The workers from all stone crushing mills were classified in five groups (SEG1-5) depending on level of dust exposure. The risk of exposure was different in each work position as shown in Table 1.

Table 1 Stone crushing mills SEG listing

SEG	Work position	Code	Sampling points
Stone removal	Employees and contractors involved in the removal of product stones	SEG1	37
Stone crushing mill	Employees and contractors performing inspection and monitoring tasks	SEG2	85
Separating stones from soil	Employees and contractors separating stones from soil	SEG3	55
Field maintenance	Employees and contractors undertaking electrical and mechanical maintenance activities predominantly in the production areas	SEG4	45
Surface cleaners	Employees and contractors performing any other tasks on the surface	SEG5	58

List of inclusion and exclusion criteria for the trial To be eligible to participate in this study, individuals met all of the inclusion criteria listed below.

- Provision of signed and dated informed consent form
- Over 18 years of age
- Able to speak and read Thai
- When any individual met any of the exclusion criteria listed below, they were excluded from participating in this study
- Having an intermittent period of work in a stone crushing mill, such as a stopping to work for other jobs
- Working as a subcontractor

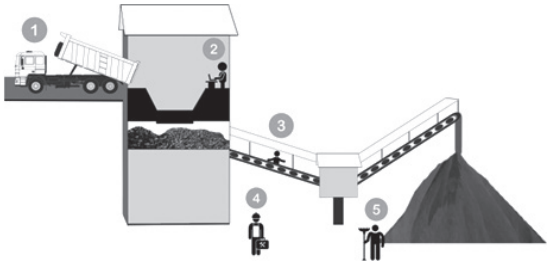

Figure 1 Similar Exposure Groups.

Instrument development

An instrument to collect data was verified using the Index of Consistency (IOC) by three occupational safety and health specialists. The four parts of the study are described below.

Demographic factors

Individual data from 302 workers were collected using a self-administered questionnaire. All questions were multiple choice or fill in the blank.

Predisposing, enabling and reinforcing factors

Predisposing factors were any characteristics of a person that motivates behavior before or during the occurrence of that behavior consisting of ten items of knowledge about dust hazard and preventive health behaviors regarding dust exposure and 20 items of perception. Enabling factors were any characteristics of the environment that facilitated action and any skill or resource required to exhibit a specific behavior consisting of ten items. The independent variables were reinforcing factors, meaning rewards or punishments following or anticipated as a consequence of a behavior consisting of five items. Therefore, the questionnaire comprised a total of 45 items. Knowledge about dust hazard and preventive health behaviors regarding dust exposure questions consisted of ten items. All items offered a binary choice (Yes or No). Kuder-Richardson 20 (KR-20)[13] was used to analyze reliability which was 0.894. Because a KR-20 value greater than 0.8 it exhibited good reliability[14]. In all, 35 items employed a Likert Scale[15]. These items were analyzed using Cronbach's Alpha Coefficient revealing reliability due to a value greater than 0.8[14].

Preventive health behaviors regarding dust exposure

Preventive health behaviors are defined as any activity undertaken by an individual who believes that one can be healthy by preventing hazards such as wearing a mask to prevent dust etc. The questionnaire consisted of ten items. All items employed a Likert Scale[15]. Cronbach's Alpha Coefficient was used to analyze reliability which was 0.822 indicating good reliability[14].

Respirable dust concentration in the working area

The respirable dust samples were collected using a personal sampling pump (UL listed model) with aluminum cyclone and PVC membrane filter of 5.0 μm pore size. This equipment was calibrated to a flow rate of 2.5 L/min as shown in Figure 2. The information on respirable dust concentration is presented in Table 2.

Figure 2 Personal air sampling in each working area

Table 2 The concentration of respirable dust at the SEG1 to SEG5 (n=280)

SEG	Task positioning	Number of workers	Personal air samplings (point)	Respirable dust concentration (mg/m^3)		
				Max.	Min.	Mean
SEG1	Stone removal	59	37	41.71	2.47	14.39
SEG2	Stone crushing mill	52	85*	24.85	0.25	6.41
SEG3	Separating stones from soil	40	55*	48.46	0.57	12.79
SEG4	Field maintenance	83	45	42.44	1.01	7.26
SEG5	Surface cleaners	68	58	36.76	0.25	4.32

** As for field maintenance, they have moved to another workstation especially workstation SEG 2 and SEG 3 to verify that equipment is working according to the manufacturer recommendation.*

Statistical analysis

Descriptive statistics including mean, standard deviation and percentage was used to explain the characteristics of each study variable. Inferential statistics included Pearson's Correlation Coefficient and linear regression analysis was applied to test the hypothesis.

Ethics consideration

Ethics approval was obtained from the Thammasat University Ethics Review Committee for Human Research Subjects (certified code: 016/2561).

Results

A descriptive study of the subjects

The population characteristics consisted of 302 workers, average age 42 years who had been working in stone crushing mills. The subjects consisted mainly of males (66.9%) and the most had been working in the stone crushing mill more than 10 years (32.1%, $\bar{x}$=8.35, S.D.= 9.15) in the position of field maintenance (27.5%) at the production process, eight hours daily (75.8%, $\bar{x}$=8.40, S.D.=1.35). The education level of workers were principally primary school (58.6%), was and the majority were married (68.2%). Evidence showed that these subjects presented normal health status without respiratory diseases before coming to work (94.1%). Most never smoked before (52.0%) including no secondhand smoke exposure (37.8%). One half did not take physical activity (50.6%). Knowledge, about preventive health behaviors regarding dust exposure of workers, was interpreted using the criteria of Bloom[16]. They exhibited a good level of knowledge (93.4%, $\bar{x}$=9.10, S.D. =0.95), but were unaware of preventive health behaviors regarding dust exposure (65.2%, $\bar{x}$=5.18, S.D. =2.53). In addition, they had a moderate level of perceived susceptibility, perceived severity, perceived benefits, perceived barriers, reinforcing factors and were unaware of enabling factors.

Relationship between independent variables and preventive health behaviors regarding dust exposure factors

The findings revealed that education level, history of respiratory diseases, history of smoking, secondhand smoke exposure, physical activity, work experience in the stone crushing mill, daily working hours, perceived susceptibility, perceived severity, perceived benefits, perceived barriers, reinforcing factors, enabling factors, respirable dust concentration in the working area, respirable dust concentration in the working area compared with the Occupational Safety and Health Administration (OSHA) Standard, and respirable dust concentration in the working area compared with the American Conference of Governmental Industrial Hygienists: (ACGIH) Standard related to preventive health behaviors regarding dust exposure of workers are shown in Table 3. The results from Pearson's Correlation Coefficient indicated only seven independent variables were significantly associated with preventive health behaviors regarding dust exposure of workers and were added in the regression analysis model as shown in Table 4. The regression analysis model formula is shown in Equation (1). All model variables could explain the preventive health behaviors regarding dust exposure of workers. The positive associated factors included

enabling factors (X_1), perceived barriers (X_2), working hours daily (X_5), perceived susceptibility (X_6), and respirable dust concentration in the working area (X_7). The negative associated factors included history of smoking (X_3) and physical activity (X_4). This equation could predict the preventive health behaviors regarding dust exposure of workers by 44.7% (R^2=0.447). The formula obtained using multiple regression analysis model is shown below.

$$Y= -4.683 + 0.169X_1 + 0.238X_2 - 0.467X_3 - 0.326X_4 + 0.264X_5 + 0.202X_6 + 0.029X_7 \quad (1)$$

where

Y = the preventive health behaviors regarding dust exposure (total 10 marks)

X_1= enabling factors (total 40 marks), X_2 = perceived barriers (total 20 marks), X_3 = history of smoking (no smoking = 1, have smoked, but not smoking now = 2, currently smoking = 3), X_4 = physical activity (everyday = 1, 3 to 5 times/weekly = 2, 1 to 2 times/weekly = 3, no physical activity = 4), X_5 = working hours daily (hours), X_6 = erceived susceptibility (total 20 marks), and X_7 = respirable dust concentration in the working area (mg/m^3)

Table 3 Relationship between independent variables and preventive health behaviors toward dust exposure (n=302)

Independent Variables	Pearson's correlation	*P*-Value*
Education level	0.119	0.038
History of respiratory diseases	-0.132	0.022
History of smoking	-0.163	0.005
Second-hand smoke exposure	-0.121	0.036
Physical activity	-0.236	0.000
Work experience in stone crushing mill	0.126	0.028
Working hours daily	-0.130	0.024
Perceived susceptibility	0.281	0.000
Perceived severity	0.140	0.015
Perceived benefits	0.308	0.000
Perceived barriers	0.238	0.000

**p*-value 0<0.05

Table 3 Relationship between independent variables and preventive health behaviors toward dust exposure (n=302) (cont.)

Independent Variables	Pearson's correlation	*P*-Value*
Reinforcing factors	0.484	0.000
Enabling factors	0.379	0.000
Respirable dust concentration in the working area	0.173	0.004
Respirable dust concentration in the working area compared with OSHA	0.230	0.000
Respirable dust concentration in the working area compared with ACGIH	0.213	0.000

**p*-value 0<0.05

Table 4 Regression analysis model (n=302).

Independent Variables	Unstandardized Coefficients		*t*	*P*-Value*
	B	Std.Error		
Constant	-4.683	1.259	-3.720	0.000
Enabling factors (X_1)	0.169	0.020	8.525	0.000
Perceived barriers (X_2)	0.238	0.056	4.273	0.000
History of smoking (X_3)	-0.467	0.129	-3.628	0.000
Physical activity (X_4)	-0.326	0.100	-3.257	0.001
Working hours daily (X_5)	0.264	0.065	4.087	0.000
Perceived susceptibility (X_6)	0.202	0.073	2.763	0.006
Respirable dust concentration in the working area (X_7)	0.029	0.013	2.344	0.020

R=0.668 R^2=0.447 Std.Error=1.857 F=15.256 **P-Value 0<0.05*

Discussion

Most subjects were male (approximately 66.9%), because this type of industry involves heavy industry, so males are needed for work more than the females. They had no exercise or little time for physical activity (approximately 75.8%) probably due to working eight or more hours daily (approximately 96.3%). In addition, almost 80% reported having achieved low education levels making them less aware of

preventive health behaviors regarding dust exposure in their work (approximately 65.2%). Preventive health behaviors were classified using the criteria of Bloom[16]. However, the results from the workers' responses indicated that these workers had a good level of knowledge (approximately 93.4%) about preventive health behaviors, because these workers were regularly trained regarding safety at work by a safety officer.

History of smoking was negatively correlated with preventive health behaviors regarding dust exposure (r = -0.467, p = 0.000), indicating that nonsmokers may be aware of the risk of exposure to make them cautious concerning preventive health behaviors to protect their health. This was similar to the study of Surattana Pornvivattanachai[17] reporting nonsmokers were more aware of the dangers of smoking than those who smoked.

Physical activity was negatively correlated with preventive health behaviors regarding dust exposure (r = -0.326, p = 0.001). The workers, not exercising or spending little time for physical activity, may probably have more protective health behaviors in the working area. They perceived they had good health already which according to health belief model[18] stated that the motivation of a person to behave in a healthy manner was due to the need to avoid illness or injury that threatens health.

Perceived susceptibility was positively correlated with preventive health behaviors regarding dust exposure (r = 0.202, p = 0.006) because the subjects were more aware of the potential risk of exposure to dust in their workplace. Therefore, they also had better preventive health behaviors regarding dust exposure. Becker et al.[19] and Piyanuch Boonviset et al.[20] found that perceived susceptibility related to preventive health behaviors regarding incense dust exposure.

Working hours daily (hours) was positively correlated with preventive health behaviors regarding dust exposure (r = 0.264, p=0.001), indicating that the subjects had an average working hours at around 8.4±1.35 hours in one day. Most worked 8 hours (75.8%), followed by more than 8 hours daily (20.5%). Most had overtime work, for which the long term exposure to dust might have caused a greater impact on the health of workers than on short periods of time when they had unsafe behaviors in preventing dust exposure[21]. Similarly, Supawan Saisut et al.[22] and Rajnarayan R et al.[23] stated that the working hours related to preventive health behaviors regarding asbestos exposure in car garages, where working hours also correlated with the results of lung function tests among stone crusher workers in India.

Perceived barriers were positively associated with preventive health behaviors

regarding dust exposure (r=0.238, p=0.001), resulting from perceived barriers to the dangers of dust in the workplace. Therefore, the subjects also decreased preventive health behaviors regarding dust exposure similar to Becker et al.[19] who stated that behavioral expression was reduced when an action was tricky and costly. In addition, Boontarika Inwanna et al.[24] also found that perceived barriers in performing dust protection was associated with preventive health behaviors regarding dust exposure among rice mill workers.

Enabling factors (ability to access the respiratory protection equipment of individuals, policies to promote the use of respiratory protective equipment, health communication and annual health check-up) were positively associated with preventive health behaviors regarding dust exposure (r = 0.169, p = 0.001), due to the easy accessibility of the resources mentioned above to make the subjects protected from dust in the workplace[25]. Siriwan Ruenbanthoeng[26] indicated that enabling factors related to preventive health behaviors regarding dust exposure of construction projects among Mass Rapid Transit Bangkok workers. In addition, it was consistent with Brian HW Guo et al.[27] who stated that safety motivation influenced workers' safety behaviors in New Zealand.

Respirable dust concentration in the working area was positively associated with preventive health behaviors regarding dust exposure (r = 0.029, p = 0.020), resulting from working areas had a high concentration of dust. Therefore, the subjects employed increasingly protected behaviors from dust exposure. Similarly, Boontarika Inwanna et al.[24] found that perceived barriers in performing dust protection was associated with preventive health behaviors regarding dust exposure among rice mill workers.

Nine variables were eliminated from the regression analysis model. As a result, these variables were important for preventing health behaviors regarding dust exposure at a lower level when compared with the seven variables. Therefore, it would be useful for stone crushing mills to select the most appropriate sequence of dealing with significant variables associated with the preventive health behaviors regarding dust exposure.

Conclusion

Seven significantly influenced variables could be used to predict preventive health behaviors regarding dust exposure of workers at 44.7%. Therefore, efforts to manage those influencing variables would involve designing appropriate activities to reduce undesirable health behaviors of dust exposure. The limitation of this study was the lack of data concerning personal air sampling in the working area due to budget constraints. Therefore, SEGs were used to estimate the

concentration of respirable dust in the working area.

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ปัจจัยที่มีความสัมพันธ์กับพฤติกรรมการป้องกันสุขภาพจากการรับสัมผัสฝุ่นของพนักงานโรงโม่ในจังหวัดสระบุรี ประเทศไทย

กมลวรรณ สมณะ[*] อารุญ เกตุสาคร[**]

บทคัดย่อ

วัตถุประสงค์ของการศึกษาเพื่อประเมินปัจจัยที่มีความสัมพันธ์กับพฤติกรรมการป้องกันสุขภาพจากการรับสัมผัสฝุ่นของพนักงาน การศึกษานี้เก็บข้อมูลช่วงเดือนมีนาคมถึงสิงหาคม พ.ศ. 2561 จากพนักงานจำนวน 302 คน ที่ปฏิบัติงานใน 26 โรงโม่ เก็บข้อมูลโดยใช้แบบสอบถามที่ผู้วิจัยพัฒนาขึ้นและตรวจวัดความเข้นของฝุ่นละอองขนาดเล็กในพื้นที่การปฏิบัติงาน สัมประสิทธิ์สหสัมพันธ์เพียร์สันและการวิเคราะห์การถดถอยนำมาใช้ในการวิเคราะห์ข้อมูล ผลการศึกษาพบว่ามี 16 ปัจจัยที่มีความสัมพันธ์กับพฤติกรรมการป้องกันสุขภาพจากการรับสัมผัสฝุ่นอย่างมีนัยสำคัญทางสถิติที่ระดับ 0.05 และนำ 16 ปัจจัยที่มีความสัมพันธ์เข้าตัวแบบการวิเคราะห์การถดถอย พบว่ามีเพียง 7 ปัจจัยเท่านั้น (ประวัติการสูบบุหรี่, การออกกำลังกาย, ชั่วโมงการทำงานต่อวัน, การรับรู้โอกาสเสี่ยงของการเกิดโรค, การรับรู้ต่ออุปสรรคของการปฏิบัติ, ปัจจัยเอื้อ, และปริมาณความเข้มข้นของฝุ่นละอองขนาดเล็กในพื้นที่การปฏิบัติงาน) ที่มีอิทธิพลต่อพฤติกรรมการป้องกันสุขภาพจากการรับสัมผัสฝุ่น ตัวแบบการวิเคราะห์การถดถอยสามารถพยากรณ์พฤติกรรมการป้องกันสุขภาพจากการรับสัมผัสฝุ่นของพนักงานได้ร้อยละ 44.7(R^2=0.447) ดังนั้นควรพยายามเพื่อจัดการปัจจัยที่มีอิทธิพลโดยการออกแบบกิจกรรมที่เหมาะสมเพื่อลดพฤติกรรมสุขภาพที่ไม่พึงประสงค์จากการรับสัมผัสฝุ่น

คำสำคัญ: พฤติกรรมการป้องกันสุขภาพ ฝุ่นละอองขนาดเล็ก โรงโม่ พนักงาน การรับสัมผัสฝุ่น

วารสารสาธารณสุขศาสตร์ 2562; 49(2): 234-248

[*] สำนักงานป้องกันควบคุมโรคที่ 4 สระบุรี

[**] คณะสาธารณสุขศาสตร์ มหาวิทยาลัยธรรมศาสตร์