American Journal of Public Health Research, 2018, Vol. 6, No. 2, 57-61
Available online at http://pubs.sciepub.com/ajphr/6/2/6

DOI:10.12691/ajphr-6-2-6

A Case of Non-Occupational Silicosis from 3-Year Surveillance at Stone Crushing Factories Neighboring Communities in Surin Province, Thailand

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Abstract This study is descriptive research. The objective of the study was to monitor silicosis and follow upon subjects in neighboring communities of a stone crushing factory in Mueang District, Surin Province, Thailand for three years. The study applied chest x-ray examination and reports by ILO classification for pneumoconioses. Also, the environmental inspection was performed through air monitoring sampling on 24-hour basis by Air Metrics/Model: TAS 5.0 S/N 5547 between 2014-2016. Subjects of this study were 10-years old and older, residing within 5-kilometer radius around the factory, and along the road that was used by gravel trucks from the factory. The total subjects were voluntary 1,602 persons with consenting to the chest radiographing. The results of air monitoring sampling during 2014-Year 2016 are 0.049, 0.035 and 0.032 average of PM_{10}, respectively. TSP results were 0.014, 0.074 and 0.078 respectively and did not exceed standards limit.The health surveillance findings of voluntary subjects were from 1,602 persons, at 61.15 % out of population at potential risk affected by stone dust on 2,620 persons. The results of chest radiograph by ILO classification pneumoconioses revealed that 13 cases (0.81%) were Categories 1 (profusion 1/0, 1/1, 1/2), 2 cases (0.12%) were Categories 2 (profusion 2/1, 2/2, 2/3) respectively. The results from 3-year surveillance of abnormal chest radiograph reports of profusion 1/0-2/2 group of 6 cases indicated 1 case with confirmation of profusion 1/1 silicosis (0.06%) of at-risk population, and non-occupational silicosis. In conclusion, silicosis surveillance from chest radiograph reports by ILO classification pneumoconioses, and by two NIOSH reports found 1 case was confirmed 1 non-occupational profusion PP 1/1 silicosis. However, reports found 5 profusion 1/0 - 2/2 cases (0.19%) and required continuous monitoring. The study needed further monitoring to include population in silicosis-risk zone.

Keywords: *silicosis, pneumoconioses, ILO classification, Surveillance, Surin Province, Thailand*

Cite This Article: Sarawan Porgpermdee, Fareeda Potchanakaew, and Saowalak Chaiyo, "A Case of Non-Occupational Silicosis from 3-Year Surveillance at Stone Crushing Factories Neighboring Communities in Surin Province, Thailand." *American Journal of Public Health Research*, vol. 6, no. 2 (2018): 57-61. doi: 10.12691/ajphr-6-2-6.

1. Introduction

Silicosis is a lethal irreversible fibrotic lung disease. Problem awareness is recognized worldwide, especially in low income country. It is under reported in undeveloped country from little surveillance as in the reference [1]. Silicosis is caused by inhalation of crystalline silica dust particle that trigger lung parenchyma to become fibrotic lead to chronic respiratory insufficiency and death. Silicosis firstly is claimed to be an occupational disease but now it extends to the public. Occupational silicosis mainly is reported in mining as in the reference [1]. Non-occupational silicosis exposures occur in non-industrial workplaces such as in farming, construction and demolition work. Non-occupational exposures from industrial dust were found in sand stones mining and milling, silica flour milling as in the reference [2]. Depend on the geologic place, agricultural soils mostly composed of crystalline silica (CSi) and silicate materials as in reference [3]. Lung diseases, such as tuberculosis and lung cancer are often reported in people expose with silica as in the reference [1]. There are three type of silicosis; acute, accelerate and chronic. It is most common found in the chronic form, who contacts silica more than a decade. More than a million workforces in the world suffer from silicosis as in the reference [1]. International Labour Organization (ILO) and World Health Organization (WHO) have policy to prevent the occurrence of silicosis patients worldwide. The policy is set to achieve goal in 2030. ILO/WHO GPES (Global Program Elimination of Silicosis) was established in 2007. Many countries, including Thailand joined the program. Thailand initiated Silicosis Prevention Surveillance Program in 2001 and has been run by the Bureau of Occupational and Environmental Diseases, Department of Disease Control, Ministry of Public Health, Thailand. The data revealed 252,268 cases of silicosis at-risk in the sandstone factories in 2012 and increased to 264,479 cases in 2014 while uncertain number of

non-registered workers were not included. In 2015, reports by the Strategy and Planning Division, Ministry of Public Health, Thailand and the National Health Security Office, Thailand revealed that 234 patients with silicosis and 30 fatal cases of non-registered workers were found in sandstone-carving community in Sikhio District, Nakhon Ratchasima Province, Thailand. There are still reports of cases in other provinces, for instance, Nakhon Sithammarat, Mahasarakham, Lopburi, Songkhla and Bangkok, Thailand.

Surin Province is the natural source of Basalt stone, formed by volcanic rock, which contains silica at 45-55% as in the reference [5]. Crushed stone industries are found in 2 districts; Mueang District and Prasat District, Surin Province, Thailand. These industries were locally established 25 years ago. Currently, there are 6 stone crushing factories and a compressed concrete factory located close to the 4 communities in Mueang District, Surin Province. Villagers are affected by dust from production process and possibly by logistics process and agricultural occupation in silica-based zone. Additionally, tight end funds mineral concession is now allocated to support health care fund for local residents. Besides, the National Health Security Office, Thailand has provided funds in some years. Budget allocation for occupational disease clinic program in Surin Province is spent to initiate chest x-ray examination in the communities for silicosis surveillance. From the mutual monitoring of local public health service stations in 2014, silicosis cases were found by chest radiograph reports which indicated non-occupational silicosis from non-occupational exposures or non-occupational exposures from industrial dust. The onsite monitoring program and strict countermeasure are designed to lower silicosis problems. The countermeasure has been focused on primary and secondary prevention in the communities.

2. Research Objectives

1. To monitor silicosis and follow up on subjects in neighboring communities near to stone crushing factory in Mueang District, Surin Province, Thailand by chest radiographs and reports by using the ILO classification for pneumoconioses between 2014 and 2016.
2. To inspect environment by air monitoring sampling of dust volume in the neighboring communities of the stone crushing factory in Mueang District, Surin Province between 2014 - 2016.

3. Materials and Methods

This study was descriptive research that studied subjects residing within 5-kilometer radius around stone crushing factories in Mueang District, Surin Province, Thailand. The data were collected from 4 subdistricts; Moo 8, Baan Krathom, Moo 15 Baan Nongkrathom, Moo 16 Baan Khoksa-ard, Moo 9 Baan Tra-ngon, with total number of 2,620 persons, between 2014 and 2016.

3.1. Inclusion Criteria

The study population lived within 5-kilometer radius around the factories, and along the road that was used by gravel trucks from the factory, and never worked in stone crushing factories or a compressed concrete factory. Study-population selection was designed to include females and males, 10-years old and older, and voluntarily to join with the program, and consented to the chest radiographing.

3.2. Exclusion Criteria

People residing outside study areas in the year 2014 to 2016 when the study was conducted.

3.3. Equipment

1. Chest radiograph on mobile unit, featured with an X-Ray machine/ Model: Sedecal, a Digital Receiver & Converter/Model: CANON (DIGITAL RADIOGRAPH). Results of Chest Radiograph Reports by using the ILO Classification for pneumoconioses, classified into 3 categories 12 subcategories as in the reference 6 [6] by NIOSH B medical specialist readers.
2. Environmental Inspection by air monitoring sampling in the communities at 24-hour basis, 1 day, 1 time per year. The applied device was Air Metrics Model: Tas-5.0 S/N 5547 performed by a specialist from the 9th Health Center, Nakhon Ratchasima Province, Thailand.

3.4. Statistic Analysis

Data were edited and analyzed by using the per centage.

3.5. Limitation

1. Funding and data collection were from different organizations between 2014 and 2016. Meanwhile, there was organizational change concerning authority in charge which affected on collaboration and following up the surveillance, also the cooperation for future tertiary prevention.
2. The Chest Radiograph Reports took long time. In a certain year took 12 months due to the shortage of NIOSH B reader.

3.6. Ethical Issue

Oral consent was collected prior to the chest x-ray examination. Ethical consideration was approved by the Board of Human Research Ethics, Surin Hospital, Thailand.

4. Result

Of 2,620 eligible silicosis-risk subjects, 1,602 voluntary subjects (61.15%) were included in the study. Findings of health monitoring from 2014 to 2016 indicated that in 2014, 139 chest radiograph reports by using the ILO classification of pneumoconioses from 1,602 voluntary subjects were classified as group Categories 1 (profusion 1/0, 1/1, 1/2) in 5 cases (3.60%) and Categories 2 (profusion 2/1, 2/2, 2/3) in 1 case (0.72%), respectively. By 2015, total 909 voluntary subjects were reported; and

marked group Categories 1 was found in 5 cases (0.55%), Categories 2 in 1 case (0.11%), respectively. Finally, in 2016, 554 voluntary subjects were reported Categories 1 in 3 cases (0.54%). However, the analysis of the chest radiograph reports of categories 1 and 2 from 2014 to 2016 indicated that 1 case with Categories 1 profusion PP (1/1) was silicosis (0.06%) as shown in the Table 1.

Table 1. Results of Chest Radiograph by using the ILO Classification of Pneumoconioses

PROFUSION/YEAR	2014	2015	2016	TOTAL
0/0-0/1	133	903	551	1,587
1/0-1/2	5	5	3	13
2/1-2/3	1	1	0	2
TOTAL	**139**	**909**	**554**	**1,602**

Report: By the 2 NIOH B medical specialist readers .
The first reader reported the results of the year 2014 .
The second reader reported results from the year 2015 to 2016 .
The number of participating subjects varies depending on the amount of gross budget resources.

As the results from 3-year surveillance, chest radiograph reports of the voluntary subjects indicated 6 cases with Categories 1 -2, out of 1,602 persons, 0.37%, aged 57-76 years (1 case relocated in Categories 2 later after the program commenced) were marked. Furthermore, 1 case was diagnosed silicosis symptom; profusion PP 1/1 silicosis (0.06 %). Besides, 153 cases (9.55%) were reported with marked problems of respiratory organs. Additionally, we found the differences between the reports of 2 NIOSH B medical specialist readers, and from the B reader between 2014 and 2016. In conclusion, author confirmed third year report read by 2 NIOSH B readers. From medical record, the patient was a farmer and has never worked in the stone crushing factories.

The surveillance of air quality was conducted by using air monitoring and sampling on a 24-hour day per year basis from 2014 to 2016. The results complied with standard limits as shown in the Table 2.

Table 2. Results of 24-hour air monitoring sampling in risk area

DUST	2014	2015	2016	Average*
$PM_{10}(mg/m)^3$	0.049	0.035	0.032	0.12
TPS $(mg/m)^3$	**0.014**	**0.074**	**0.078**	**0.33**

PM_{10} :Particulate Matter
TSP: Total Suspended Particulate
Air quality standards of Notification of National Environmental Board No.24 (2004) [7].

Results of air monitoring and sampling by the 9th Health Center, Nakhon Ratchasima Province collected 1 time per year from 2014 to 2016, complied with standard criteria. The PM_{10} through human's airway was likely lower. The TSP included100 micron or smaller dust that increased in 2015 and 2016.

5. Discussion

The surveillance of population in 4 neighboring countries nearby stone crushing factories, non-occupational and non-exposure to silica. The surveillance activities covered 60% of population at risk. Dust monitoring was performed on 24-hours a day, 1 time per year basis, in every 3 consecutive years. The findings on date of inspection complied with standard limits. However, findings were not be able to indicate the average daily dust volume, and/or period at maximum volume. Thus, dust alert to residing people was impossible. They could be affected by accumulated dust from the stone crushing factories for over 25 years since its establishment.

Chest x-ray examination and reports by ILO classification for pneumoconioses is a reputable, inexpensive and appropriate method for silicosis screening though high-resolution computed tomography (HRCT) is better recognized for pneumoconioses in term of the sensitivity of the diagnosis as in the references [8,9,10]. In ILO 0/0 radiographs, HRCT could find abnormal opacities and low-grade silicosis, but they cannot be excluded as in the reference [11]. Lung pathology study revealed silicosis condition despite that chest radiograph report aligns with ILO 0/0 as in the reference [12]. As a consequence, the surveillance of the individuals' residents at risk is highly required along with dust prevention inside and outside workplaces, and home and community environmental monitoring.

Chest radiographs were reported by using the ILO classification for pneumoconioses was carried out by mobile x-ray unit, operated by technician from Surin Hospital, Thailand every year. The reports were read by the 2 medical specialist readers from the NIOSH. We also found variations in radiographic readings from both inter-observer and intra-observer, as ILO recognition as in reference [6]. To improve silicosis surveillance and secondary prevention of silicosis, more ILO experts are needed, especially in this specific area.

Environmental surveillance was performed by periodically, 1 time per year. The results of the 3 consecutive years complied with the standard limits. PM_{10} levels through human airways likely decreased, while the total suspended particulate (TSP) levels increased in 2015 and 2016, five times higher than of the year 2014. The stone demand was likely increased. Stone production and transportation volumes were increased to align with the demand.

The patient record showed that the patient was a farmer with non-exposure history to silica. He was classified as patient with non-occupational silicosis. He possibly exposed to non-industrial or industrial silica dust. However, the definite diagnosis required pathological results. Silica found in lung, soil and workplaces required the laboratory tests.

As a result of the surveillance, we found a case with potential risk of silicosis and abnormal respiratory organ functions. This case needed health care taking from the medical teams for tertiary prevention.

Consequently, each individual at risk required health and environmental surveillance as secondary prevention for silicosis. Ultimately, the primary prevention towards dust control; both in house and off- site of the workplaces, personal protective equipment (PPE) wearing enforcement, and home and community care should be enforced as well.

In Thailand, presently, there is no laws and regulations concentrated on standard or permitted levels of the silica dust exposures in workplaces and communities. Instruments for silica dust monitoring and detection are lacking and

uncovering countrywide. The workplace control is operated by different organizations and different ministries. For instance, control for machines and instruments is processed by the Ministry of Industry, whereas the individual occupation registration is performed by the Department of Welfare and Labour Protection, Ministry of Labour. When the people in the communities are hypothetically affected by the environmental waste products, the concerned local authorities will be in charge depending on local administration's judgement.

After reporting a case with silicosis from the surveillance zone in Mueang District, Surin Province, Thailand, there was an increase of the awareness to all sectors in terms of primary and secondary prevention as in the reference [13]. To clarify, the control of machines and stone crushing production process is reinforced by dust elimination. Closed system factory is initiated following by water dust shield installation. Additionally, there are dust collectors on the wheels and the covering of the truck. Also, people are encouraged to plant trees in the factories and residential areas to prevent dust. Workers and dust exposure villagers are encouraged to wear PPE. Secondly, Ministry of Public Health, Thailand has implemented secondary prevention continuously to screen silicosis patients by chest x-ray examination by using the ILO International Classification of Radiographs for Pneumoconioses. Furthermore, adequate dust control measures were performed. Thirdly, tertiary prevention as in the reference [13], for instance, silicosis case transferring to the chest disease specialists.

The most effective management depends on primary and secondary prevention as in the reference [13]. Further attempts are required to gain recognition and to control for silica exposures. To control occupational and non-occupational silica dust exposures, the environmental surveillance should be performed to assess the appropriate control for silica dust exposures. Besides, health surveillance for silica dust contact people should be implemented. Silicosis is still fatal disease; comprehensive management is needed to diminish new case and slows the progression of the irreversible respiratory symptoms of the patients.

6. Conclusions

1. Based on 3-year surveillance, and results reported by the 2 NIOH B readers, it was indicated that 1 case with Categories 1 profusion PP (1/1) silicosis was found (0.06 % of the total population) in the at-risk agricultural zones.

2. Results of PM_{10} and TSP levels from environment measurements by air monitoring and sampling in the communities during 24-hour periods in 2014 to 2016 complied with standard limits.

7. Suggestion

1. Further studies of similar target populations living in the neighboring residents are recommended.

2. Surveillance of people in risk areas is recommended to cover and carry out continuous surveillance. Follow-up care should be provided for those with a history of various abnormalities, including pulmonary function tests.

3. Since the variability of chest radiograph readings by using the ILO International Classification for Pneumoconioses, two or more NIOSH B readers are needed to read the chest radiographs.

4. Regular dust and silica dust monitoring is recommended. The monitoring should be performed in the factories, logistic routes, and surrounding areas, generally. In addition, local air sampling and monitoring station is recommended as the data from the station will be applied for the future surveillance measurement in the communities.

5. Enforcement of the Regulations is recommended. State government authorities must be defined to strictly control the entire system.

6. With the government concern, constructive solutions for the collaboration for silicosis prevention and control should be established to comply with the ILO and WHO policies to prevent the epidemics of new cases by 2030.

Acknowledgements

The kind supports from all study volunteers for participation in this program, information provision and care services delivery from concerned authorities are sincerely appreciated.

Statement of Competing Interests

There is no conflict of interest in this study declared.

Abbreviation

CSi: Crystalline Silica
GPES : Global Program Elimination of Silicosis
HRCT : High Resolution Computed Tomography
ILO: International Labour Organization
NIOSH B reader: A physician certified by the National Institute for Occupational Safety and Health (NIOSH) as demonstrating proficiency in classifying radiographs of the pneumoconioses.
PM10: Particulate Matter
PPE: Personal Protective Equipment
TSP: Total Suspended Particulate
WHO: World Health Organization

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