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# Radiographic Progression among Sandstone Workers: A Preliminary Result

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**Abstract** **Objective:** To describe the radiographic progression among sandstone workers exposed to respirable crystalline silica (RCS). **Methods:** The sample of 134 sandstone workers had at least 2 chest radiographs between January 2012 and April 2017. Their chest radiographs were assessed from the first through last visits to find two or more steps subcategory progression. All films were interpreted and classified by two physicians, who were qualified as NIOSH B readers according to International Labor Office System of Classification of Radiographs of Pneumoconiosis 2011 (ILO/ICRP). **Results:** Progressions were demonstrated among 30 (22.4%) workers as they had radiographic evidence of two or more step subcategory progression and 5 out of them had 2-times progression. The median duration of exposure was 10.0 years (IQR 8.0-15.0) (range 2.0-25.0). The median duration of follow-up was 31.0 months (IQR 20.0-38.0) (range 6.0-54.0) **Conclusions:** Our findings revealed that chest radiograph had progressed in 22.4% of patients over the median 10 years of exposure; nevertheless, the association between exposure duration and radiographic progression could not be described in this study.

***Keywords:*** *chest radiograph, ILO classification, pneumoconiosis, progression, sandstone worker, silicosis*

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## 1. Introduction

Silicosis is an occupational lung disease caused by inhalation of respirable crystalline silica (RCS) and it can progress even after silica exposure has discontinued [1]. RCS is a lifelong risk for the development of pulmonary tuberculosis in the absence of silicosis, even after exposure to silica dust ends [2]. Silicosis was one of the most important occupational health problems identified by the International Labor Organization (ILO) and World Health Organization (WHO). This was the focus of their joint Global Elimination of Silicosis Campaign [3].

The incidence of silicosis among sandstone workers continues to increase year-on-year in Thailand due to uncontrolled level of RCS in working environments and unconcerned to use respirators [3-5]. By contrast, the incidence of silicosis in developed countries has been declining because RCS is limited through administrative controls by policies and health surveillance guidelines for RSC exposures are performed [6,7,8,9]. Then, chest radiographs are known to be an essential element of medical surveillance programs for RSC exposures [6,7,8,9].

Only a few studies have reported the radiographic progression among workers exposed to silica dust in different occupational groups [10-18]. Sandstone workers are one of the high-risk occupation for developing silicosis but has been no studies with respect to the radiographic progression of the disease among sandstone workers in Thailand. The high turnover rate of sandstone workers might a difficulty when conducting studies among these workers.

The objective of this study was to describe the radiographic progression among sandstone workers. The results of the study might help potentially affected workers to implement more effective preventions.

## 2. Methods

### 2.1. Study Population

The study population included sandstone workers exposed RCS at work in Sikhiu District, Nakhon Ratchasima Province, northeastern, Thailand, and registered at silicosis surveillance program at Sikhiu Hospital between January 2012 and April 2017. The number of sandstone workers accountable for 134, aged more than 18 years old and exposed to RCS for more than one year, were required to have at least two chest radiographs to see whether there was any progression. Data obtained from medical records included age at initial chest radiography, smoking history, interval between initial and most recent chest radiograph, duration of exposure to silica dust and duration of exposure since the most recent chest radiograph.

## 2.2. Chest Radiographic Assessment

Chest radiographs were interpreted by two NIOSH B Readers [19]. The final decision was made by consensus if there was disagreement between the readers. The readers interpreted all chest radiographs using side-by-side assessment, in which they viewed all films together in known temporal order, and compared them with the ILO standard films. The International Classification of Radiographs of Pneumoconioses 2011 (ILO/IRCP) was used to classify only parenchymal abnormalities (small and large opacities) [20].

## 2.3. Outcome Measurement

The outcome of interest was progression of chest radiographs, duration of exposure and time to progression, which was calculated by subtracting the month of the sandstone workers' first visit in the program from the month of the first detection of the progression of the film. Progression was defined as (a) an increase of two or more steps on the 12-point scale of profusion of small opacities, (b) a one-step in the size of small or large opacities, (c) the development of large opacities not previously present.

## 2.4. Statistical Analysis

Data were analyzed using descriptive statistics. The results were presented as median, interquartile range (IQR) and frequency (%). All analyses were performed using Stata version 10.

## 2.5. Ethical Consideration

The ethical concern was primarily with respect to confidentiality of personal data. The present study was reviewed and approved by Khon Kaen University Ethics Committee in Human Research (HE591385).

# 3. Results

The chest radiographs of 134 sandstone workers, who met the inclusion criteria, were interpreted by NIOSH B Reader. The median was 45.0 years (IQR 39.0-53.0). Seventy-two (53.7%) were smokers. The median duration of exposure was 10.0 years (IQR 8.0-15.0), with a range from 2-25 years. The median duration of follow-up was 31.0 months (IQR 20.0-38.0), with a range from 6-54 months, as shown in Table 1.

**Table 1. Baseline characteristics**

| Characteristics | N=134 |
|---|---|
| Age (years, median (IQR)) | 45.0 (39.0-53.0) |
| Sex (n, %) | |
| Male | 99 (73.9%) |
| Female | 35 (26.1%) |
| Smoking (n, %) | |
| Yes | 72 (53.7%) |
| No | 62 (46.3%) |
| Duration of exposure (years, median (IQR)) | 10.0 (8.0-15.0) |
| Duration of follow-up (months, median (IQR)) | 31.0 (20.0-38.0) |

**Table 2. Parenchymal abnormalities at first and last visit**

| Parenchymal abnormalities | Total 134 n (%) | |
|---|---|---|
| | First visit | Last visit |
| No | 57 (42.5%) | 51 (38.1%) |
| Small opacities | | |
| -/0 | 0 (0.0%) | 0 (0%) |
| 0/0 | 0 (0.0%) | 0 (0%) |
| 0/1 | 18 (13.4%) | 9 (6.7%) |
| 1/0 | 11 (8.2%) | 9 (6.7%) |
| 1/1 | 10 (7.5%) | 15 (11.2%) |
| 1/2 | 20 (14.9%) | 15 (11.2%) |
| 2/1 | 10 (7.5%) | 12 (9.0%) |
| 2/2 | 5 (3.7%) | 14 (10.4%) |
| 2/3 | 2 (1.5%) | 7 (5.2%) |
| 3/2 | 1 (0.8%) | 0 (0%) |
| 3/3 | 0 (0.0%) | 2 (1.5%) |
| 3/+ | 0 (0.0%) | 0 (0%) |
| Large opacities | | |
| A | 8 (6.0%) | 9 (6.7%) |
| B | 10 (7.5%) | 11 (8.2%) |
| C | 1 (0.7%) | 2 (1.5%) |

**Table 3. Number, duration of exposure and time to progression of chest radiographic change in two or more steps subcategories**

| Progression | Number (N=35*) | Duration of exposure (years) | | Time to progression (months) | |
|---|---|---|---|---|---|
| | | Median (IQR) | Ranges | Median (IQR) | Ranges |
| No to 1/0 | 2 | 12.5 (11.2-13.8) | 10.0-15.0 | 34.5 (32.8-36.3) | 31.0-38.0 |
| No to 1/2 | 1 | 5.0 | - | 46.0 | - |
| No to 2/2 | 1 | 17.0 | - | 54.0 | - |
| No to A | 2 | 8.5 (6.8-10.3) | 5.0-12.0 | 48.0 (45.5-50.5) | 43.0-53.0 |
| 0/1 to 1/1 | 5 | 12.0 (12.0-15.0) | 10.0-15.0 | 31.0 (11.0-46.0) | 7.0-52.0 |
| 0/1 to 1/2 | 1 | 12.0 | - | 38.0 | - |
| 0/1 to A | 1 | 10.0 | - | 31.0 | - |
| 1/0 to 1/2 | 1 | 15.0 | - | 31.0 | - |
| 1/1 to 2/1 | 1 | 18.0 | - | 23.0 | - |
| 1/1 to 2/2 | 1 | 20.0 | - | 7.0 | - |
| 1/2 to 2/2 | 7 | 15.0 (13.5-15.0) | 10.0-25.0 | 23.0 (14.0-31.0) | 7.0-38.0 |
| 1/2 to 2/3 | 2 | 14.0 (12.0-16.0) | 10.0-18.0 | 36.0 (35.0-37.0) | 34.0-38.0 |
| 1/2 to A | 1 | 18.0 | - | 31.0 | - |
| 2/1 to 2/3 | 1 | 15.0 | - | 38.0 | - |
| 2/1 to A | 1 | 15.0 | - | 51.0 | - |
| 2/3 to 3/3 | 1 | 10.0 | - | 19.0 | - |
| A to B | 5 | 15.0 (10.0-15.0) | 8.0-15.0 | 19.0 (7.0-31.0) | 5.0-31.0 |
| A to C | 1 | 15.0 | - | 34.0 | - |

* 5 out of 30 workers had 2 times progression.

The profusion of small opacities and duration of exposure in all workers at their first and last visit were classified, as shown in Table 2. Overall, 30 workers (22.4%) had radiographic evidence of progression and 5 out of them had 2-times progression. Then, Thirty-five subjects met the criteria for radiographic progression. Subgroup analysis was performed in these subjects to compare the median duration-of-exposure and time-to-progression from the change in profusion in two or more subcategories. No matter how many progressions of workers had, any change in profusion in two or more subcategories was analyzed, as shown in Table 3. Four workers had no parenchymal abnormalities, while two in 0/1, one in 1/1, one in 1/2 and one in 2/1 had a radiographic change of more than 2 subcategories, respectively.

## 4. Discussion

The present study focused on progression of chest radiographs, duration of exposure and time to progression among sandstone workers. The main findings of the current study revealed that 22.4% of the sandstone workers had radiographic evidence of two or more steps subcategory progression over the 10.0 years median duration of exposure and the median duration of follow up of 31.0 months. The percent change in the current study was lower than the previous studies investigating the progression of silicosis, which varied in ranges from 24 to 65% [10-18]. In those studies, there were some differences in occupation, concentration of RCS, durations of exposure, durations of follow up, definition of radiographic progression and methods of radiographic assessment [10-18].

We found that progression from a higher category was more likely associated with longer periods in duration of exposure and shorter periods in time to progression. On the other hand, the greater than two steps progression was conversely periods relative to two steps progression. However, chest radiography still took time to show the progression.

We were not able describe the association between duration of exposure and radiographic progression due to the limited number of workers at each step of progression. There are also some reports that could not show such association, which include those concerning silicosis among iron-ore miners [12] and silica flour packers [17], which contradicts the results concerning silicosis among sandblasters [10] and slate pencil workers [11].

Another limitation of the current study was that we were unable to determine the precise year of onset of parenchymal abnormalities. It is possible that the onset may have been several years prior to being registered in the silicosis surveillance program.

We suggests that further study of chest radiographic progression be done by increase the sample sizes, change definition of radiographic progression such as an increase in profusion of at least one subcategory or new development of a large opacity and use other method for statistical analysis such as logistic regression or survival analysis.

## 5. Conclusions

Our findings revealed that chest radiograph had progressed in 22.4% of patients over the median 10 years of exposure; nevertheless, the association between exposure duration and radiographic progression could not be described in this study.

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## Statement of Competing Interests

The author has no competing interests.

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