

A cluster onset of acute and accelerated silicosis cases in workers of ramming mass industries in Jharkhand, Eastern India

Dharmendra Singh¹, Samit Kumar Carr², Bidisa Sarkar³, Syed Irfan Ali⁴, Kamalesh Sarkar⁵

¹Department of Biochemistry, ICMR-National JALMA Institute for Leprosy and Other Mycobacterial Diseases, Agra, Uttar Pradesh, India, ²Occupational Safety and Health Association of Jharkhand (OSHAJ), Jamshedpur, Jharkhand, India, ³Department of Community Medicine, Gouri Devi Institute of Medical Sciences and Hospital, Durgapur, West Bengal, India, ⁴Department of Community Medicine, Manipal Tata Medical College, Manipal Academy of Higher Education, Jamshedpur, Jharkhand, India, ⁵ICMR-National Institute of Occupational Health, Ahmedabad, Gujarat, India

ABSTRACT

Introduction and Methodology: A cross-sectional study was conducted among workers of ramming mass industries in the East Singhbhum district of Jharkhand, eastern India. Workers had occupational exposure to respirable crystalline silica dust of varied duration between 1 and 6 years. A total of 122 subjects participated in it. Relevant epidemiological information was collected from them. All were x-rayed using 300 mA radiation for the detection of the presence of silicotic opacities if any as described by the International Labour Organisation (ILO) for the detection of silicosis. **Results:** The study revealed that 61.4% (n = 75) of subjects had silicosis. Of them, 19 had acute silicosis (having a duration of silica dust exposure of 2 years or lesser) and 56 had accelerated silicosis (a duration of occupational exposure of > 2 to 6 years). The offending agent was clouds of respirable crystalline silica dust from the ramming mass industries. **Epidemiological Interpretation:** To the best of our knowledge, this is the first report of an outbreak of acute and accelerated silicosis cases because of occupational inhalational exposure to ramming mass in India with a sizable portion of female workers with silicosis. Regional as well as national authorities need to take appropriate interventional measures in a programmatic mode as soon as possible. **Conclusion:** An in-depth investigation on the existence and magnitude of the problem of silico-tuberculosis is needed to be performed in them as silicosis increases the vulnerability of pulmonary tuberculosis among the affected workers.

Keywords: Accelerated silicosis, acute silicosis, CC-16, ramming mass, silico-tuberculosis

Introduction

Jharkhand, one of the eastern Indian states, is rich in minerals. However, it suffers from what is sometimes termed a resource curse:^[1] It accounts for more than 40% of the mineral resources

of India,^[2] but 39.1% of its population is below the poverty line and 19.6% of children under 5 years of age are malnourished.^[3] A number of ramming mass industries are located in the state, particularly in the Musaboni, Dumuria, Potka, and Dhalbhumgarh blocks under the East Singhbhum district of the state. An estimated number of 800 workers including migrant workers were involved with the above-said ramming mass industries in the district for their livelihood. Of them, an estimated number of 200 workers were reported to have died after suffering from breathlessness, fever, weakness, chest pain, and so on for a

Address for correspondence: Dr. Kamalesh Sarkar, ICMR-National Institute of Occupational Health, Ahmedabad, Gujarat, India. E-mail: kamalesh.sarkar@gmail.com

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few years after being exposed to silica dust from the ramming mass industries. It was revealed that death was more among the migrant workers living within the factory premises, which was probably associated with their entire day and night exposure to the clouds of silica dust within the factory premises including during non-working hours additionally. Following the reported sufferings and deaths of workers, some workplaces were closed down, and some were shifted to other newer places because of local communities' protests against the deaths and sufferings of workers. A few social activists came forward and networked with local communities for demanding governmental actions including compensation. Following community protests, some factories closed down and/or moved to other newer adjacent areas.

Ramming mass or quartz ramming mass is *the mixture of boric acid, silicon dioxide, or silica* as an element of rocks in the structure of pure deposits. The mixture of ramming mass contains various sizes of fine silica dust particles ranging from 0.06 mm and below and granules of 0.20 mm to 0.06 mm, 1 mm to 0.20, and 4 mm to 1 mm [Figures 1 and 2].^[4] Actually, silicon dioxide and silica are intertwined in ramming mass as all are produced while breaking, crushing, sieving, and milling of crystalline quartz having 98.9% to 99.99% silicon dioxide (SiO₂). Ramming mass and silica are the main constituents of refractories and refractory materials used in induction furnaces, manufacturing of ladle and cradle transfer cars for making ingots of iron and cast iron, and so on. It is also used for making electric porcelain insulators. The role of acidic ramming mass in steel melting through an induction furnace is very important. Because of its important property to withstand thermal shocks without developing any cracks because of interrupted power supply, which is the case throughout our country, crystalline quartz having 99.90% silicon dioxide (SiO₂) is manufactured under strict quality control and calcined to eliminate the spalling tendency in a stabilized form, where silica neither expands nor contracts. It is suitable for withstanding higher temperatures up to 1720 degree centigrade.

Silicosis is an irreversible and progressive occupational respiratory disease caused by continuous or intermittent inhalation of respirable crystalline silica dust while working in



Figure 1: Raw Quartz stone for making ramming mass

relevant industries. Acute silicosis is characterized by the rapidly progressive condition when workers are exposed to very high concentrations of silica dusts along with high silica content. Its latency period is from a few months to less than 2 years. Accelerated silicosis occurs after exposure to large amounts of clouds of dust (with relatively higher silica content) over a shorter period of time with a latency period of less than 10 years.^[5,6] In contrast, chronic silicosis, which is widely prevalent in India, takes 10 to 15 years or more to develop depending on the silica content of the inhaled dust, the average daily concentration of dust in workplaces, and the duration of exposure from the onset of exposure to the day of investigation for silicosis.

Against the above backdrop, this study was conducted to understand the existence and magnitude of the problem of acute and accelerated silicosis among the workers of the ramming mass industries in the affected blocks of Jharkhand.

Methodology

It was a community-based cross-sectional study. A total of 122 workers with a past history of working in ramming mass industries were subjected to this study. Written informed consent was obtained from each study participant prior to initiating this study. Relevant epidemiological information was collected from the study subjects using a field-tested questionnaire. This was followed by x-raying of their chest using 300 mA radiation for detection of the existence of silicosis if any as per ILO Radiography criteria. Also, about 4 cc. blood samples were collected from each of them after taking prior written consent for testing serum club cell protein 16 (CC-16) as a proxy marker of their existing silicotic lung damage status as performed in a study carried out by ICMR-NIOH.^[7,8] Club cell protein 16 (CC-16) was tested using enzyme-linked immunosorbent assay (ELISA).

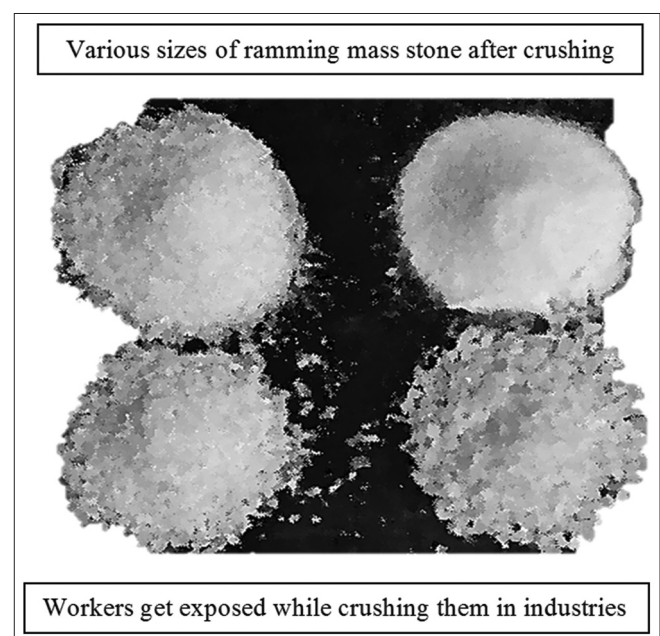


Figure 2: Ramming mass after crushing & milling before use

Data were edited and entered on the same day of collection to avoid possible errors because of recall bias. Data were analyzed using Epi Info software, version 7.2. IEC approval was obtained before initiating this study.

Results

Age-wise distribution is shown in Table 1. Most workers belonged to 41–50 years and 51–60 years' age groups. About 27% belonged to 31–40 years, and only 4% were less than 30 years.

Sex-wise, 71 workers were male (58.1%) and 51 were female (41.8%). Of them, 46 (64.7%) and 29 (56.8%) were detected to be suffering from silicosis among male and female workers, respectively.

The mean duration of work among the study subjects was 3.2 years, which ranged between 1 and 6 years. Thirty-eight workers had a working duration of 2 years or less; the rest had a duration of more than 2 years but up to 6 years. Surprisingly, it was observed that 50% (n = 19) of the workers having 2 or lesser working duration had X-ray-confirmed silicosis, whereas the same was 66.6% (n = 56) among workers having a work duration of more than 2 years [Table 2]. The former group may be considered acute silicosis, and the other group may be having accelerated silicosis considering their working and duration of exposure (less than or equal to 2 years and more than 2 years) in the ramming mass industries.

Following the guideline of the International Labour Organisation (ILO)^[9] for diagnosing silicosis using chest radiography, a total of 75 subjects had silicotic opacities as certified by the trained physicians having training on ILO radiography for the detection of silicosis. Surprisingly, it was observed that 31 out of 75 (41.3%) x-ray-confirmed silicotic subjects had normal CC-16 levels [Table 3] in contrast to the declined serum CC-16 level of chronic silicosis.

Discussion

Age-wise, about 31.9% of the study participants had an age group of 41 to 50 years, followed by 27.8% of 51 to 60 years and 26.6% of 31 to 40 years. Sex-wise, 72 study participants were male and 51 were female. On the other hand, there were 75 x-ray-confirmed silicotic subjects along with occupational silica dust exposure; 29 were female workers (38.6%). This indicates that a sizable portion of workers were female and also suffering from silicosis. This is in contrast to the reported incident of chronic silicosis where male workers almost always play the dominant role and female workers are hardly visible. The authority needs to view this alarming situation seriously to protect their required needs apart from providing services for the prevention and control of silicosis.

Silicosis is an occupational lung disease following an exposure to respirable silica dust. Chronic silicosis is widely prevalent in

this country, which usually takes on an average of 15 years or more to develop following exposure to respirable crystalline silica dust with a silica content between >5 and 30%. However, to the best of our knowledge, this perhaps is the first report of an outbreak of acute and accelerated silicosis caused by exposure to clouds of silica dust while working in ramming mass industries. In this study, 122 silica dust-exposed workers were subjected to assess their lung health by chest radiography and serum CC-16 level as a proxy marker for assessing silicotic lung damage. It may be noted that ICMR-National Institute of Occupational Health (ICMR-NIOH), by their earlier study, had conclusively evidenced that serum CC16 may be used to categorize and/or quantify the silicotic lung damage.^[7,8] It may be noted that CC16 is a lung protein, secreted from the terminal bronchiole, having anti-inflammatory properties.^[10-12] The question remains how a normal serum CC16 value is possible in some acute/accelerated silicotic workers? Literature review suggests that acute silico-proteinosis occurs in acute silicosis in an attempt to repair the silicotic lung damage if exposure is short. Consequently, this may result in repairing of lung tissue by overcoming the damage, particularly if damage is not extensive (exposure is high but for a shorter period). A further in-depth investigation is needed to explore on this.

Table 1: Distribution of study participants by age group (n=123)

Age group	Number	%
<30 yrs.	5	4
31-40 yrs.	33	27
41-50 yrs.	39	31.9
51-60 yrs.	34	27.8
61-70 yrs.	11	9
All age groups (total)	122	

Table 2: Distribution of acute and accelerated silicotic subjects

Duration of work	No. of subjects	X-ray confirmed silicosis (%)
2 year or lesser	38	19 (50%) (Acute Silicosis)
>2 to 6 years	84	56 (66.6%) (Accelerated Silicosis)
Total	122	75 (61.4%)

Table 3: CC-16 level and x-ray confirmed silicosis in subjects with acute and accelerated silicosis

Category of subjects based on chest x-ray and serum CC-16 level	Actual no.	%
X-ray positive silicotic subjects with serum CC-16 value <12 ng/ml	44	36
X-ray positive silicotic subjects with serum CC-16 value ≥12 ng/ml	31	25.4
X-ray negative healthy subjects with serum CC-16 value <12 ng/ml	27	22.1
X-ray negative healthy subjects with serum CC-16 value ≥12 ng/ml	20	16.3
Total	122	

Considering the duration of exposure to crystalline silica dust in ramming mass industries, acute silicosis (exposure of 2 years or lesser duration) was detected to the tune of 50% (19/38) among the concerned exposed workers [Table 2]. Similarly, accelerated silicosis (exposure of duration of >2 and up to 6 years) was detected in the tune of 66.6% (56/84).

A review of the literature revealed a distinctive feature in acute silicosis cases. There may be a higher chance of pulmonary tuberculosis in acute silicosis compared to chronic silicosis.^[13,14] A sporadic case with bilateral pneumothorax as a complication of acute silicosis was reported occasionally after being admitted to a hospital in Uttar Pradesh.^[14] There is the presence of a surfactant-like liquid in the alveoli in acute silicotic subjects.^[5] The basic function of surfactant-like protein is to repair the epithelial injury of the lung caused by the offending agents including silica dust. CC-16 is also an antioxidant, anti-inflammatory, and anti-fibrotic protein, associated with the repair of lung epithelial tissue.^[15] This probably explains why some acute and accelerated silicotic subjects have normal serum CC16 values in spite of having silicotic opacities in chest x-ray as observed in this study. This was probably attributed to a self-repair process of epithelial cells as a response observed exclusively in acute and accelerated silicosis.^[16] It may be noted that the study participants belong to an indigenous tribal population (Santal Adivasi) with stronger survival ability than the general population at large in adverse physical and environmental situations.

Further in-depth study is needed to explore why some acute/accelerated silicotic subjects have better lung conditions as indicated by normal serum CC16 levels, while others have declined levels in contrast to all having declined serum CC-16 levels in chronic silicosis as observed in the earlier studies. It was observed that 27 subjects had chest x-ray negative, but serum CC16 was below 12 ng/ml [Table 3]. They may be considered as sub-radiological silicosis, which usually takes further time to appear as radiological silicosis if exposure continues. It may be noted that in the absence of pathological examination or lung biopsy, sub-radiological silicosis may be considered in workers having the presence of three factors – history of considerable occupational exposure to silica dust, absence of radiological evidence of silicosis (X-ray negative for silicosis), and a serum CC16 level below 12 ng/ml in the absence of current smoking habit. In this study, no subject had a history of present or past smoking habits. To date, sub-radiological silicosis is never considered as an important opportunity for intervention^[10] for secondary prevention of at least three diseases of public health importance – pulmonary tuberculosis, silicosis (radiological), and silica-induced lung cancer. Hence, required attention needs to be given to sub-radiological silicosis, particularly if the elimination of tuberculosis needs to be achieved in the near future. Table 3 also shows another group of 20 subjects having serum CC16 more than 12 ng/ml, who may be considered healthy subjects without significant lung damage.

Finally, this study may be considered a special situation of cluster onset of acute and accelerated silicosis cases, hardly reported

earlier with tremendous public health importance. Earlier, the country was used to witness a large number of chronic silicotic workers, which usually takes a long time of 15 years or more to develop following exposure to respirable crystalline silica dust (chronic silicosis). To the best of our knowledge, this appears to be the first report of acute and accelerated silicosis cases from India, where workers develop silicosis as low as within 2 years or lesser duration following exposure to silica dust with very high content of silica (up to 99% or higher). All the affected workers had typical symptoms of shortness of breath, fever, cough, weight loss, and so on. Surprisingly, some people with acute/accelerated silicosis have relatively stable health, while a few people died shortly following the development of the disease with/without associated pulmonary tuberculosis. It is pertinent to remember that silicotic subjects (including sub-radiological silicosis) are at higher risk of pulmonary tuberculosis for the rest of their lives even after cessation of silica dust exposure due to their damaged lung immunity as was observed among gold miners of South Africa.^[17-19]

Considering the huge burden of silicosis in India, the elimination of tuberculosis by 2025 as mandated by the Govt. of India appears to be difficult to achieve unless required attention is given to control of silicosis.^[20] Worker education must be a vital aspect of an effective control program. Workers including their family members, trade union leaders, workplace safety staff, and so on should be informed of the hazardous nature of silica flour, the results of workplace monitoring and periodic medical screening, and the correct usage and maintenance of respirators. Packaged silica flour should be labeled correctly, and health warnings should be placed on each container to alert users and handlers as well as producers to the hazards of silica flour.

Primary health care workers need to learn about various types of silicosis – acute, accelerated, and chronic – their causation and mechanism of detection using ILO radiography and other methods,^[21] the relationship between silicosis and pulmonary tuberculosis, and so on. One should not forget to explore both silicosis and silico-tuberculosis among workers if there is a history of occupational silica dust exposure for a considerable period. We need to remember that unless silicosis is controlled, elimination of tuberculosis from our country is not possible as a sizable number of pulmonary tuberculosis cases are perhaps hidden within them.^[22] Considering the fact that occupational health is a neglected subject in India, all primary health care workers need to be trained on early detection of commonly prevalent occupational diseases with special focus on silicosis.

Authors' contribution

DS planned and supervised the entire laboratory work. SC and BS executed the field study and made the initial drafting of the manuscript. SIA supervised fieldwork and did the clinical evaluation of study participants and KS conceptualised and guided all the situations whenever needed and approved the final version of the manuscript.

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Conflicts of interest

There are no conflicts of interest.

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