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# SILICOSIS: A CURSE THAT NEEDS IDENTIFICATION

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**ABSTRACT** Silicosis is a well-known occupational lung illness that is frequently found in silica dust-exposed industries like stone mining, sandblasting, quarrying, ceramics, and other industrial jobs like grinding, oil and gas, brick- and pottery-making and fiberglass production. It is frequently characterized by coughing and shortness of breath. It is sporadically linked to tumors, tuberculosis (TB) and lung cancer-causing agents like mycobacterial infections, autoimmune illnesses, etc. One of the most common occupational diseases in the world, silicosis poses serious health risks to employees, especially in developing nations like India.

**KEYWORDS :** Silicosis, lung disease, prevention, types, symptoms

## INTRODUCTION

Respirable crystalline silica (RCS), also known as Potter's Rot or Grinder's Disease, is the primary cause of the occupational lung disease silicosis [1]. The most typical form of silicosis is diffuse nodular pulmonary fibrosis. The inhalation and deposition of RCS particles, or particles with a diameter of <10 μm, is what causes this lung condition, which can occasionally be asymptomatic [2]. Both crystalline and amorphous forms of silica occur, with the latter having a comparatively lower toxicity profile and being exposed to less frequently [3]. There are various polymorphs of crystalline silica that naturally exist in a polymerized tetrahedral framework. One of the oldest occupational diseases in existence is silicosis [4].

In 2010, Italy reported the first incidence of silicosis linked to synthetic stone; since then, cases from Israel, Australia, Spain and the USA have all been documented on a rapid international scale.

Before any symptoms appear, the illness damages the lungs permanently. Even after exposure has ended, the disease it causes could still get worse. Additionally, silicosis lowers a patient's resistance to chronic obstructive pulmonary disease, renal disease, arthritis, lung cancer and tuberculosis (TB) [1]. Carefully documented records of occupational exposure and radiological characteristics are required for the diagnosis of silicosis, and any competing diagnoses must be ruled out [5]. The Kolar Gold mines' pneumoconiosis issues were first discussed in 1933, and the first incidence of silicosis was documented in 1947 [6].

In India, there are around 3 million workers who are exposed to silica dust, while, 8.5 million more are employed in the construction industry with similar exposures. Due to the Indian Supreme Court's views, the subject has recently attracted attention.

The People's Rights and Social Research Center filed a Public Interest writ petition to alert the court to the issue of silicosis in India [7]. When silica dust is inhaled in significant volumes over an extended period, a potentially fatal, irreversible fibrotic lung illness called silicosis can develop (Figure 1) [8].

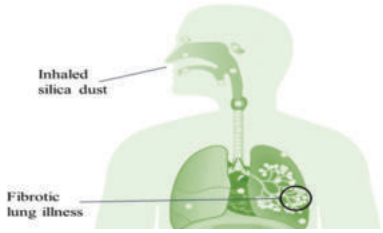


**Figure 1:** Irreversible Fibrotic Lung Illness (silicosis) Can Be Developed By Inhaled Silica Dust

Compared to healthy patients, those who are exposed to silica have a 2.8-39 times higher risk of developing pulmonary tuberculosis. Numerous studies have proven that those who have been exposed to silica are susceptible to TB. The amount of free silica dust present in the workplace directly correlates with the prevalence of tuberculosis, and exposure to silica for longer periods of time increases the chance of developing the disease.

A fibrotic lung disease called silicosis is brought on by breathing in crystalline silica (Silicon dioxide, SiO2). Earthen matter contains silicon, which is the second most prevalent element. Two atoms of silicon and oxygen combine to make silicon dioxide, often known as silica (SiO2). The element that is most plentiful in clay material is oxygen. In soil, SiO2 is widely distributed in a variety of materials, including rock, sandstone, slate, granite, gneiss, and metallic ores, as well as sand, mortar, plaster, and roofing shingles [9]. Silicosis is one of the most significant occupational diseases in the world due to widespread inadequate technological protection measures that, from the past to the present, expose countless people over long periods of their life [10].

Since there is no known cure for silicosis, available therapies concentrate on avoiding consequences. Huge efforts have been made recently to better understand the pathogenetic mechanisms underlying

silicosis [11]. One of the most significant occupational health conditions in the world is silicosis. It is a lung condition that worsens over time and is brought on by chronic silica inhalation. Shortness of breath, coughing, fever, and bluish skin are signs of silicosis. A common and well-known pneumoconiosis brought on by silica inhalation is silicosis [12].

## TYPES OF SILICOSIS

There are primarily three types of silicosis (Figure 2):

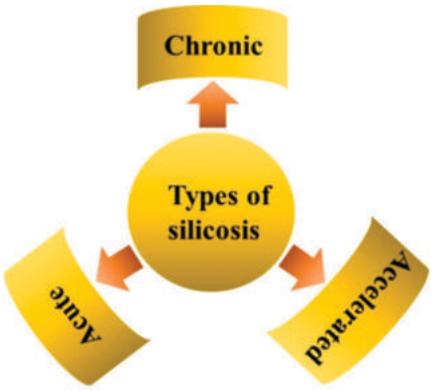


**Figure 2: The three major types of silicosis are chronic, accelerated and acute**

### Chronic

This type of silicosis is the most prevalent and develops after 15 to 20 years of only minimal to moderate exposure to RCS (Table 1). Some common side effects of silicosis include rheumatoid arthritis, chronic obstructive lung disorders and tuberculosis [13,14].

**Table 1: Diseases associated with respirable crystalline silica (RCS) exposure (Adapted from [14])**

| Disease | Respirable crystalline silica (RCS) exposure | Comment |
|---|---|---|
| Type of silicosis | | |
| Chronic nodular silicosis | Minimal RCS<br>More than ten years of latency | Pulmonary nodules with a diameter of 10 mm<br>Usually without symptoms |
| Progressive enormous fibrosis (chronic complex silicosis) | Minimal RCS<br>More than ten years of latency | Pulmonary nodules are larger than 10 mm<br>Radiological severity-related symptoms and progression |
| Accelerated (fast-moving) silicosis | Medium to high-level RCS<br>More than ten years of latency | A disease that progresses more quickly than chronic silicosis<br>Symptoms of simple, complex and acute silicosis could be present |
| Acute silicosis or silico-proteinosis | Extremely high-level RCS<br>Develops from weeks to five years | Alveolar proteinosis-related characteristics<br>Elevated death rate |
| Additional pulmonary diseases | | |
| Lymphadenopathy | Lowest exposure or duration not known | Whether or not parenchymal silicosis is present<br>Calcification might exist |
| Sarcoidosis | | Linked to RCS exposure<br>Possibly challenging to distinguish from complex silicosis |
| Lung cancer | Relationship between dose and reaction after RCS exposure | If smoking is present, the risk is almost multiplicatively enhanced<br>May manifest even if silicosis is not present |
| The Caplan syndrome | | Combination of pneumoconiosis with rheumatoid arthritis or increased rheumatoid factor |
| Infection with mycobacteria | | |
| Respiratory tuberculosis | | TB risk might increase by 2.8 to 39 times, depending on the degree of silicosis |
| Immune disorder | | |
| Rheumatoid arthritis | | Risk is three times higher for men than for those who are not exposed to RCS |
| Scleroderma | | Systemic sclerosis development in males exposed to RCS, with or without silicosis (RR 3.02)<br>Autoantibodies against DNA topoisomerase 1 are more common |

Accelerated silicosis is no longer frequent in wealthy nations, but small-scale mining poses a severe health risk in developing nations [15].

### Acute

Chronic cor pulmonale, chronic respiratory failure and acute silicosis pulmonary hypertension. In the case of severe fibrosis, these consequences develop quickly. It also goes by the name of "silico proteinosis" and develops in a few weeks to five years as a result of exposure to high quantities of respirable silica dust. The signs include a sudden onset of acute breathlessness, coughing, weakness and weight loss, which frequently results in death [9].

## SYMPTOMS OF SILICOSIS

These conditions are linked to silicosis symptoms:

- Tuberculosis (TB)
- Shortness of breath
- Fatigue
- Loss of appetite (anorexia).
- Chest pain; dry with non-productive cough (Whooping Cough)
- Respiratory failure
- Ultimately results in death

## PREVALENCE IN INDIA

In 574 gold miners, silicosis prevalence was 29.1% (95% confidence interval [CI]: 24.8-33.4%, 167 cases), with 97 stage I, 54 stage II (29 cases with stage II and 25 with stage IIþ) and 16 stage III silicosis [16]. There have been reports of various occupational groups with significant silica dust exposures having a high prevalence of accelerated silicosis [17,18]. Privately owned gold mining operations in China have a high incidence of silicosis, which is linked to extremely high silica dust exposure levels [19].

In India, silicosis is common among construction and mining workers in Gujarat, Rajasthan, Pondicherry, Haryana, Uttar Pradesh, Bihar, Chhattisgarh, Jharkhand, Orissa and West Bengal. In India, the prevalence of silicosis varies greatly, from 3.5% in an armoury to 54.6% in the slate-pencil business. This variance in prevalence is caused by the silica concentrations in various work environments, the length of exposure and the demands of the jobs. In a quartz mill in Gujarat's Godhra district, 14% amongst 85 female workers with an average age of 28.2 (þ9.2) years were found to have silicosis, according to recent research [20]. The likelihood of contracting silicosis is higher in developing nations like Brazil, China, India and Vietnam. In India, the danger of silicosis is significant in the slate pencil and agate grinding industries, for example, the prevalence is higher in workers at Kolar Gold Fields in Karnataka.

## SILICOSIS PROBLEM IN RAJASTHAN

More over 1.65 million families in Rajasthan work in mines and quarries for pitiful wages, making up a significant portion of the state's labor force. Most of these workers are exposed to a variety of occupational health risks, but silicosis, an incurable lung disease

brought on by breathing in silica dust, has reached epidemic levels. Many workers were between the ages of 41 to 50 years, followed by 31 to 40 years and then 51 to 60 years. Similar to this, the majority of workers worked for 11 to 20 years, then 21 to 30 years, and finally >30 years.

## SILICOSIS PROBLEM IN HARYANA

Under the Factories Act of 1948 and the Building and Other Construction Workers (RE & CS) Act, 1996 [21], silicosis is a disease that must be reported in the state of Haryana. Being a progressive state, Haryana has implemented an integrated policy for integration and rehabilitation. Most silicosis-affected workers come from disadvantaged socioeconomic groups in our society. The treatment, payment, rehabilitation and provision of various welfare measures for employees with the incurable disease of silicosis are all guaranteed by this policy. The proposed Haryana Silicosis Rehabilitation Policy's implementation guidelines and details are provided below:

- This policy will apply to any employee whose silicosis has been officially diagnosed by the Haryana Silicosis Diagnosis Board.
- This policy only applies to employees working in factories and on construction sites.

Workers covered by the Employee State Insurance (ESI) Act of 1948 will get compensation in accordance with its provisions. While other workers who are not covered by that Act will receive compensation in accordance with the requirements of the Employee's Compensation Act of 1923.

In India, the prevalence of silicosis varies greatly, from 3.5% in an armory to 54.6% in the slate-pencil business. This variance in prevalence is caused by the silica concentrations in various work environments, the length of exposure, and the demands of the jobs. The bulk of the participants in this study were men [22]. In India, the state of Rajasthan provides most of the country's sandstone. In Rajasthan, there are about 30,000 mines, and more than 2.5 million people are engaged there. In mines, workers engage in a variety of tasks that expose them to silica dust at high concentrations for extended periods of time.

## EPIDEMIOLOGY

One of the most significant occupational diseases in the world, silicosis is brought on by inhaling crystalline silicon dioxide or silica [10,23]. The variety of vocations linked to silica dust exposure is so broad that the illness is prevalent throughout practically all of India. However, central and mid-western Indian states like Madhya Pradesh, Chhattisgarh, Jharkhand, Gujarat and Rajasthan are where it is most frequently recorded. Environmental and medical assessments conducted by the National Institute of Occupational Health, Ahmedabad, across India's unorganized sectors revealed a very high prevalence of silicosis [24]. Based on clinical and radiological data in particular occupational work forces, many of these investigations had described a varied prevalence of silicosis. The following are significant occupational exposures to silica dust in India:

- Construction work: sand blasting and crushing, drilling, masonry, tunnelling and grinding
- Mining - sand stone and granite drilling
- Slate pencil work
- Foundry work
- Manufacturing of ceramic and clay pottery
- Agate cutting and polishing
- Glass manufacturing

According to epidemiological research, exposure to silica raises the risk of lung, esophagus, stomach, and skin cancer [25]. In India, where the prevalence of silicosis ranges from 3.5% in ordnance factory to 54.6% in the slate pencil business, there are surprisingly few epidemiological research on the disease. In the unorganized sector of businesses like slate pencil cutting, stone cutting, and agate manufacturing, the silicosis problem is significantly more serious.

In uncontrolled sectors of the slate pencil cutting, stone cutting and agate industry, silicosis is a far more serious issue. The problem with this is that the majority of unorganized sector industries are not covered by laws like the Factories Act, which was created to safeguard the health and safety of the working population. Additionally, companies lack the motivation to give their employees a safe workplace [26]. Silicosis is the most prevalent occupational lung illness in the world; it can be found anywhere but is more prevalent in impoverished nations. China reported more than 24,000 deaths each year from silicosis between 1991 and 1995 [27]. Between one and two million American workers [28] are thought to have been exposed to crystalline silica dust at work and 59,000 of these people will experience silicosis at some point in their careers [27]. Industrial processes and disease associated with silica exposure are given in Table 2 [14,29].

According to CDC data, silicosis is exceedingly uncommon in the United States [28]. Only 187 deaths in 1999 had silicosis as the primary or contributory cause, reflecting a drop of 84% in the prevalence of silicosis-related deaths between 1968 and 1999. According to epidemiological research, exposure to silica raises the risk of developing lung, esophagus, stomach, and skin cancer [25,30].

**Table 2: Processes and activities linked with silica exposure (Adapted from [14,29])**

| Type of Exposure | Crystalline silica exposure |
|---|---|
| Industrial sources of crystalline silica | Petroleum refining |
| | Cement and brick manufacturing |
| | Glass manufacturing |
| | Soap and cosmetic production |
| | Flues |
| | Metal preparation |
| | Molding |
| | Abrasive blasting |
| | Smelting lead |
| | Mining |
| | Smelting copper |
| | Cleaning fossil fuel furnaces |
| | Steel production |
| Other sources of crystalline silica | Sculpturing stone containing granite |
| | Glassblowing |

## MODE OF INFECTION

Additionally, silicosis can raise your chance of developing other serious and sometimes fatal illnesses, like:

- Tuberculosis (TB) and other chest infections
- Pulmonary hypertension
- Heart failure
- Arthritis
- Kidney disease
- Chronic obstructive pulmonary disease (COPD)
- Lung cancer

## DIAGNOSIS

Since there is no particular test for silicosis, a diagnosis can require numerous visits and tests to the doctor. During the visit, the patient's doctor will ask about their respiration, both while they are at rest and when they are active. To assess the likelihood of silica exposure, the patient's doctor will also inquire in-depth about the patient's employment history.

It may be a good idea to prepare the following information in advance:

- Patients' symptoms of disease
- Treatments given before for the symptoms and how patients get helped by the treatmen
- The work you have done over your entire career
- The length of time you spent in each job
- The nature of the work you performe
- The products you were in contact with at work
- Patient history of smoking and any previous medical data, such as chest X-rays or CT scans

Silicosis is primarily diagnosed based on a history of occupational exposure, clinical symptoms, and chest roentgenogram roshik findings. The appearance of nodules and rounded opacities, occasionally accompanied by hilar lymphadenopathy and "egg-shell" calcification of the lymph nodes, make up the traditional chest X-ray results. The size, shape and number of nodules in the lung parenchyma are used to identify the disease stage [31]. Three factors can be used to diagnose silicosis. First, the sickness was brought on by the patient's exposure to enough silica dust. Second, an X-ray of the chest that shows silicosis. Third, the irregularities are not being caused by any underlying diseases. A complicated disease has an unremarkable physical examination [9].

For uncomplicated silicosis, a chest X-ray will establish the existence of tiny (< 10 mm) nodules in the lungs, particularly in the upper lung zones. According to ILO classification, profusion 1/0 or more with form p and q denotes silicosis-related lung injury [9]. For silicosis, there is no known treatment. The pillars of treatment include supportive therapy, which includes using bronchodilators, oxygen supplements and infection prevention [1]. People who work in occupations that expose them to inhaled silica or who are exposed to silica outside of work who have symptoms like coughing, phlegm or breathing problems or who have no symptoms (even after working for a long period), should be tested for silicosis.

A thorough occupational history, a physical exam by a healthcare professional, decreased chest expansion, diminished intensity of breath sounds, areas of hypo-resonance and fine to medium crackles in the lung area, tachypnea and other investigations for the confirmation of silicosis can all be used to diagnose silicosis. The most crucial instrument for the diagnosis of silicosis is a chest X-ray or chest radiography, which is part of the investigations. To check for related disorders such as tuberculosis (TB), lung's function tests like spirometry and sputum analysis may be required. Even so, it can be challenging to find tubercle bacilli in the sputum of silico-tuberculosis patients. Due to silicotic fibrosis, which walls in the tubercle foci and limits the release of tubercle bacilli in the sputum, this problem exists. Pulse oximetry, bronchoscopy, a high-resolution chest CT scan and lung biopsy are all used to examine the interior of the lungs.

Following a physical examination during which your doctor listens to your lungs, they may recommend several tests to see if you have silicosis. These consist of:

**Imaging tests**
The extent of the silica dust injury can be determined by a better chest X-ray image or a CT scan of the patient's lungs.

**Lung function tests**
These examinations measure how well your lungs function in terms of appropriate breathing and blood oxygenation. Spirometry and diffusion capacity tests, two different procedures are used to measure these parameters. They are also employed to estimate the extent of lung injury.

**Sputum test**
Collecting mucus from a cough for analysis.

**Bronchoscopy**
A short, flexible tube called a bronchoscope has a camera at one end. A bronchoscope will be inserted by the patient's physician through their mouth, nose, windpipe or lung. This device can be used to obtain lung tissue samples from patients for further analysis.

**Surgical lung biopsy**
This is another technique to obtain a sample of lung tissue for subsequent analysis, and it is carried out by a cardiothoracic surgeon while the patient is under general anesthesia.

## GOVERNMENT POLICIES ON SILICOSIS

According to the study, most of the workers in Thangarh are paid on a piece rate rather than a daily basis, and many employers do not view the workers as their employees because they are hired through a contractor who might not have received a license under the Contract Labor (Regulation and Abolition) Act of 1970 [32]. Only 1.6% of respondents claimed to be covered by the ESI law, even though employees must each contribute 1% and 3% of the salary bill in order to be eligible for free medical assistance. The study finds this particularly problematic considering it has been well established for more than a century that ceramic workers have higher incidences of silicosis, tuberculosis (TB), and lead poisoning [32]. If the Health Department does not have certain tests, medications or equipment needed for the treatment of the silicosis-affected worker, they may purchase it from the open market; the cost will be covered by the Labor Department.

The Gujarat government was ordered to pay compensation to the families of 238 workers who passed away from silicosis while working in unlicensed quartz crushing facilities by the Supreme Court of India on May 4. Gujarat is required to give each family 300,000 rupees or roughly $4,500 within the month. The Court further ordered the Madhya Pradesh government to provide for an additional 304 workers who are currently sufferer from silicosis [33]. Around 3.0 million workers are at high risk of exposure to silica, according to a 1999 report from the Indian Council of Medical Research (ICMR). Of these, 1.7 million works in mining or quarrying, 0.6 million make non-metallic products like refractory materials, structural clay, glass and mica, and 0.7 million works in the metals industry. Additionally, 5.3 million people work in the construction industry and are at danger of silica exposure. A well-ventilated workplace, provisions for dust protection, a decrease in overcrowding and the provision of fundamental occupational health care are all required by the Factory Act of India (1948).

The informal, unregulated industries in India that are not governed by the Factory Act of India are the biggest obstacles to eliminating silicosis. The National Human Rights Commission (NHRC) also stressed the need for regulation of the workplace and for providing workers with the necessary safety gear and health education. As a result, neither the Employees State Insurance Corporation (ESIC), the Ministry of Labor & Employment, the Government of India, nor analogous services provided by state governments provide medical coverage to those employed in the stone mining business. Therefore, if the healthcare facilities are satisfactory to both care providers and recipients, the staff may approach adjacent primary care physicians for them [34].

## TREATMENT OF SILICOSIS

If silica dust exposure continues, there is virtually any treatment to halt the progression of the condition. Corticosteroid anti-inflammatory therapy has been utilised in the past with moderate success [7,35]. Silicosis therapeutic research is progressing at a considerably slower rate than those of other chronic lung disorders. In the previous ten years, just two registered clinical trials for silicosis treatments have been completed [36,37].

A polymer known as polyvinyl-pyridine-noxide (PVNO), which can encourage cytoprotective effects in in vivo and in vitro models of silica-induced fibrosis, has also undergone extensive testing. PVNO was effective in animal models for both prevention and treatment, but it was ineffective in humans [38]. The plant alkaloid tetrandrine has also been investigated as a potential therapy for silicosis. The main mechanisms that regulate the development of the silicosis disease brought on by silica-induced lung damage include direct cytotoxicity, the production of reactive oxygen species (ROS), the secretion of inflammatory and fibrotic mediators, lung remodeling through collagen and elastin deposition, and cell death by apoptosis (Figure 3) [39]. It has historically been used to treat pneumoconiosis in Chinese medicine and the State Drugs Administration of China has approved its therapeutic usage for silicosis [39].

There are several ways to treat or reduce the symptoms of silicosis and stop it from getting worse, including:

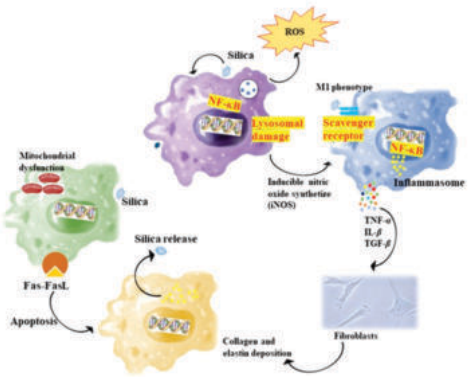


**Figure 3:** Direct cytotoxicity, production of ROS, secretion of inflammatory and fibrotic mediators, lung remodeling through collagen and elastin deposition and cell death by apoptosis are the main mechanisms that control the progression of the silicosis disease caused by silica-induced lung damage (modified from [38])

- Stop smoking and other lung irritants including silica dust and airborne silica exposure
- Use antibiotics to treat bacterial lung infections.
- Take cough suppressants

- People should be checked using a positive Interferon-Gamma Release Assays (IGRAs) blood test or a tuberculin skin test
- Extended multi-drug regimen anti-tubercular drugs for those with active TB
- Chest physiotherapy for patients to aid with mucus drainage from the bronchi
- Bronchodilators can be used to improve breathing
- Lung transplantation is the most successful treatment for replacing damaged lung tissue, however it carries danger due to long-term immunosuppression's side effects such as opportunistic infections
- Inhalation of d-penicillamine, powdered aluminium and PVNO
- Therapy with corticosteroids
- Giving Chinese herbal kombucha to patients
- Tetrandrine, an herbal extract, is used to treat silicosis or may help to delay its progression [40].

## CONCLUSION

Pulmonary and silico-tubercular diseases are very common. Given the foregoing, a national silicosis control programme is urgently required to control silicosis.

## AUTHORS' CONTRIBUTIONS

Concept and design were developed by Suresh C. Singh, and Awadesh Kumar. Data acquisition was done by Arun Kumar, and Harendra S. Bhoj. Data analysis / interpretation were done by Pankaj Yadav, Harendra S. Bhoj, and Harsh K. Singh. Manuscript drafting was done by Amit Gupta, and Amit Verma. Statistical analysis was done by Pankaj Yadav, Harendra S. Bhoj and Harsh K. Singh. Critical revision of manuscript and admin, technical or material support was done by Sonal Mishra and Rajeshwar P. Sinha. Supervision and final approval were done by Rajeshwar P. Sinha.

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## CONFLICTS OF INTEREST

The authors declare that there are no conflicts of interest in this work.

## ETHICAL APPROVALS

Not applicable.

## DATA AVAILABILITY

Data will be made available as per journal policy.

## REFERENCES

1. Leung CC, Yu IT, Chen W. Silicosis. The Lancet 2012; 379:2008-18.
2. Ziskind M, Jones RN, Weill H. Silicosis. Am Rev Respir Dis 1976; 113:643-65.
3. Steenland K, Ward E. Silica: a lung carcinogen. CA Cancer J Clin 2014; 64:63-9.
4. Mlika M, Adigun R, Bhutta BS. Silicosis [Internet]. StatPearls; 2022 [Accessed 9 February 2022]. Available from:https://www.ncbi.nlm.nih.gov/books/NBK537341/.
5. 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; 5:1-9.
6. Jones WR. Silicotic lungs: the minerals they contain. Epidemiol Infect 1933; 33:307-29.
7. Jindal SK, Aggarwal AN, Gupta AN. Dust induced interstitial lung disease in the tropics. Curr Opin Pulm Med 2001; 7:272-7.
8. Bhattacharya S, Dey A, Pal A, Kar S, Saha S. Silicosis in the form of progressive massive fibrosis: a diagnostic challenge. Indian J Occup Environ Med 2016; 20:114.
9. Mamillapalli V, Bhavani A, Padmavathi NA, Haripriya T, Bhavana D, Khantamneni PL. Silicosis-an overview. Adv J Pharm Life Sci Re 2019; 3:1-8.
10. Greenberg MI, Waksman J, Curtis J. Silicosis: a review. Dis Mon 2007; 53:394-416.
11. Gerber A, Klingelhoefer D, Groneberg DA, Bundschuh M. Silicosis: geographic changes in research: an analysis employing density-equalizing mapping. J Occup Med Toxicol 2014; 9:1-9.
12. Cullinan P, Reid P. Pneumoconiosis. Prim Care Respir J 2013; 22: 249-52.
13. Hnizdo E, Vallyathan V. Chronic obstructive pulmonary disease due to occupational exposure to silica dust: a review of epidemiological and pathological evidence. Occup Environ Med 2003; 60:237-43.
14. Rees DM, Silica J. 2017. Parkes' occupational lung disorders. In: Newman Taylor ACP, Blanc P, Pickering A (eds.), 4th edition, CRC Press, pp.187-205.
15. Tse JC, Kalluri R. Mechanisms of metastasis: epithelial-to-mesenchymal transition and contribution of tumor microenvironment. J Cell Biochem 2007; 101:816-29.
16. Tse LA, Li ZM, Wong TW, Fu ZM, Yu IT. High prevalence of accelerated silicosis among gold miners in Jiangxi, China. Am J Ind Med 2007; 50:876-80.
17. Seaton A, Legge JS, Henderson J, Kerr KM. Accelerated silicosis in Scottish stonemasons. The Lancet 1991; 337:341-4.
18. Khemakhem R, Moussa N, Kotti A, Feki W, Mnif Z, Feki W, et al. Accelerated silicosis and silico-tuberculosis: a difficult diagnosis. Clin Case Rep 2022; 10:e05482.
19. Gottesfeld P, Andrew D, Dalhoff J. Silica exposures in artisanal small-scale gold mining in Tanzania and implications for tuberculosis prevention. J Occup Environ Hyg 2015; 12:647-53.
20. Tiwari RR, Sharma YK. Respiratory health of female stone grinders with free silica dust exposure in Gujarat, India. Int J Occup Environ Health 2008; 14:280-2.
21. Haryana Government Labour Department (HGLD). 2017. [Accessed 04 January 2017].
22. Rajavel S, Raghav P, Gupta MK, Muralidhar V. Silico-tuberculosis, silicosis and other respiratory morbidities among sandstone mine workers in Rajasthan-a cross-sectional study. PLoS One 2020; 15:e0230574.
23. Mohamed N, Shamim M, Waheeb A, Tariq P. Silicosis, a monumental occupational health crisis in Rajasthan - an epidemiological survey. Int J Res Granthalayah 2017; 5:554-83.
24. Kashyap SK. Occupational pneumoconiosis and tuberculosis. Indian J Tuberc 1994; 41:73-6.
25. Yu IT, Tse LA, Wong TW, Leung CC, Tam CM, Chan AC. Further evidence for a link between silica dust and esophageal cancer. Int J Cancer 2005; 114:479-83.
26. Kulkarni GK. Prevention and control of silicosis: a national challenge. Indian J Occup Environ Med 2007; 11:95.
27. Aghilinejad M, Naserbakht A, Naserbakht M, Attari G. Silicosis among stone-cutter workers: a cross-sectional study. Tanaffos 2012; 11:38.
28. Bang KM, Mazurek JM. Silicosis mortality, prevention, and control-United States, 1968-2002. JAMA - J Am Med Assoc 2005; 293:2585-6.
29. Occupational Safety and Health Administration (OSHA). 2004. 1218-AB70-2040. Occupational Exposure to Crystalline Silica. OSHA. [Accessed 9 June 2021] Available at: http://www.osha.gov/pls/oshaweb/owadisp.show_document?.
30. Partanen T, Pukkala E, Vainio H, Kurppa K, Koskinen H. Increased incidence of lung and skin cancer in finnish silicotic patients. J Occup Med 1994; 36:616-22.
31. Shah R. 2021. Despite fatal silicosis, Gujarat ceramic hub 'evades' health insurance, minimum wage. [ONLINE] [Accessed 29 October 2021]. Available at: https://www.nationalheraldindia.com/india/despite-fatal-silicosis-gujarat-ceramic-hub-evades-health-insurance-minimum-wage.
32. Moshenberg D. For the silicosis widows of India, the struggle continues [Internet]. Women in and beyond the global; 2016 [Accessed 17 May 2016]. Available from:http://www.womeninandbeyond.org/?p=20067.
33. Iyer, S. 2020. A socio-legal understanding of state compensation for silicosis in India (Doctoral dissertation, University of Oxford). [ONLINE] Available at:https://ora.ox.ac.uk/objects/uuid:8d63956a-1d58-4e16-b206-3afaed841a89.
34. Janahi IA, Rehman A, Baloch NU. Corticosteroids and their use in respiratory disorders. Corticosteroids. London: InTech Open 2018; 23: 47-57.
35. Chen S, Liu M, Xie F. Global and national burden and trends of mortality and disability-adjusted life years for silicosis, from 1990 to 2019: results from the global burden of disease study 2019. BMC Pulm Med 2022; 22:1-10.
36. Liu WW, Wang HX, Yu W, Bi XY, Chen JY, Chen LZ, et al. Treatment of silicosis with hepatocyte growth factor-modified autologous bone marrow stromal cells: a non-randomized study with follow-up. Genet Mol Res 2015; 14:10672-81.
37. Schlipköter HW. Possibilities of causal prophylaxis and therapy of pneumoconiosis. Arch Environ Health 1970; 21:181-91.
38. Lopes-Pacheco M, Bandeira E, Morales MM. Cell-based therapy for silicosis. Stem Cells Int 2016; 5091838:1-9.
39. Steenland K, Goldsmith DF. Silica exposure and autoimmune diseases. Am J Ind Med 1995; 28:603-8.