

# **Prevalence of Silicosis in Industry Workers: A Rising Public Health Crisis**

by

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Submitted to the Graduate Faculty of the  
Department of Environmental and Occupational Health  
School of Public Health in partial fulfillment  
of the requirements for the degree of  
Master of Public Health

University of Pittsburgh

2022

UNIVERSITY OF PITTSBURGH

SCHOOL OF PUBLIC HEALTH

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2022

## **Prevalence of Silicosis in Industry Workers**

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### **Abstract**

This research aims to look into the prevalence of silicosis in industry workers in North America. Looking specifically at construction workers and those others exposed to high levels of silica dust daily. Occupational respiratory diseases are the primary cause of occupation-associated illnesses in the United States, based on the frequency, severity, and preventability of the different types of diseases. Unfortunately, these preventable diseases, that cause irreversible lung injury in many high-income countries across the world, remain under-recognized and under-researched. I wanted to look at the most prevalent issues within the working industry listed above, with various respiratory diseases. Occupational respiratory diseases account for up to 30% of all work-related diseases, and respiratory complications cause 10 – 20% of deaths. Breathing in vapors, gas, dust, and fumes at work may put workers at risk of developing a work-related lung issue. Sadly, this is a preventable issue that, by time of diagnosis, essentially has no cure. Various datasets have been examined to determine the chilling rate of silicosis diagnosis' in industrial workers and some suggestions made to better address this continuing problem.

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## **1.0 A Rising Public Health Concern**

Occupational respiratory diseases are the primary cause of occupation-associated illnesses in the United States, based on the frequency, severity, and preventability of the different types of diseases. These diseases remain underrecognized and avertable diseases that cause the lungs to fail in many high-income countries worldwide. High-income countries that have the funding and ability to spend substantially larger amounts of money on healthcare and healthcare prevention verses lower income countries. Most of these occupational illnesses are caused by repeated exposure to various particles, but even a single exposure to a hazardous agent can damage the human body (4). These diseases include various respiratory disorders with different signs, symptoms, and testing diagnostics. Occupational respiratory diseases (i.e. Pneumoconiosis, Asbestosis, allergic alveolitis, and emphysema) account for up to 30% of all work-related illnesses, and respiratory problems cause 10 – 20% of deaths. Pneumoconiosis are a group of lung diseases caused by the lung's reaction of inhaling certain dusts (4). Asbestosis is a lung disease resulting from the inhalation of asbestos particles (4). Allergic alveolitis refers to a group of lung diseases in which your lungs become inflamed due to an allergic reaction from an exposure to certain dusts (4). Breathing in vapors, gas, dust, and fumes at work may put you at risk of developing a work-related lung issue (6).

## 1.1 Occupational Respiratory Diseases

Occupational respiratory diseases are multiple different lung diseases stemming from repeated and long-term exposures to certain irritants on a working job site. These diseases are the main cause of occupation related illnesses in the United States (4). *Work-Related Lung Disease (WoRLD) Surveillance Reports* are comprehensive publications of morbidity, mortality, and workplace hazard statistics on occupationally-related respiratory diseases by geographic regions, industry and occupation, time period, and demographic group (6). In addition, the *National Occupational Research Agenda (NORA)* is a partnership to stimulate innovative research and improve workplace practices. Starting in 1996, this organization has become a framework for guiding Occupational Health and Safety research in the United States (15). Workplaces, managers, supervisors, corporate individuals, and other high-level employers, are responsible for the health of their workers and should be providing proper protection, education, and preventative measures to keep their employees safe. Occupational lung diseases are preventable when proper personal protective equipment (PPE) is used. Due to the increasing awareness of these preventable diseases and more funding into these health concerns, worker medical monitoring is easily available for workplaces to be able to monitor their buildings. Silicosis is a form of an occupational lung disease, specifically caused by inhaling crystalline silica, a dust found in the air of mines, foundries, blasting operations, stone, clay, and other ground disturbing facilities (4).

## 1.2 Silicosis

This increasingly troubling public health issue is a rising concern, especially in industry settings. As mentioned above, occupational respiratory diseases (i.e. Coal Worker's Pneumoconiosis, Asbestosis, allergic alveolitis, and emphysema) account for up to 30% of all work-related illnesses, and respiratory problems cause 10 – 20% of deaths. Not only is this an alarming percentage, but because this disease is often unrecognized, the percentage could be even higher. A recently re-emerging issue is silicosis, also known as Miner's phthisis, grinders asthma, and potters rot. According to "Silicosis in the 1990s," between 1987 and 1995, 577 people were reported to the MDPH who met the NIOSH criteria for Silicosis (19). These individuals generally had severe diseases, with most of the patients being diagnosed with massive fibrosis and tuberculosis. Nonmalignant respiratory disease (NMRD) is an overall term that includes interstitial lung disease as well as Chronic Obstructive Pulmonary Disease (COPD). This respiratory disease also arises from the exposure of airborne particles, such as particulate or dusts. The slight difference between NMRD and silicosis, is that silicosis is the occupational pneumoconiosis caused by the inhalation of crystalline silicon dioxide, specifically.

## **2.0 Silicosis: Scientific Studies**

In 2019, a silicosis upsurge among workers who cut engineered stone countertops in American kitchens and bathrooms increased rapidly. These countertops were made from a quartz-based composite to look like marble or granite. In 2019, 18 cases of severe silicosis were diagnosed, with two deaths, all in just four states among workers producing countertops (7).

Another study, starting in May of 2020, researched the screening strategies for early diagnosis of silicosis in at-risk populations in Oklahoma. Observing 600 participants enrolled in the study, those being men, 30 years of age or older, with past or present employment in dusty environments/exposure to dust at work, with the ability to consent and answer the questionnaire (“Silicosis”). Intervention tests are given to each participant, and these tests include a Tuberculosis test, a chest x-ray, and a pulmonary function test. Although this study is still occurring, the study's planned outcome measures are to estimate average cumulative respirable crystalline silica exposure, the percentage of participants who report any exposure to silica, and the prevalence of silicosis among the study groups (3). The secondary outcome measure determines if any demographic, work history or other trait correlates with increased silica exposure. This particular study is still ongoing, and it will be interesting to see the results when the investigation concludes (3).

### **3.0 The Background of Silicosis**

Crystalline silica is one of the earliest recognized and most studied occupational inhalational exposures in the United States and worldwide. Although an exact number is unknown, archeologists have found that silicosis has claimed thousands of lives of those in pre-industrial Europe. In the 1700s, Dr. Bernardino Ramazani, a physician who is considered the founder of occupational medicine, identified evidence of silicosis in stone cutters (11). It took nearly 200 years for the connection between the dust inhaled and the result of fatal illnesses to be connected by Dr. Alice Hamilton (14). However, science did not stop there, and by 1930, workers had successfully bargained to install ventilation equipment in their workshops (2). In the same year, the Gauley Bridge tunnel project became the site of one of the worst industrial disasters in United States history. Hundreds of workers died from silicosis while building the tunnel within two years of working on the project. In 1996, the Secretary of Labor began a new campaign to raise awareness to encourage a safer workplace and practice and initiated a program on silicosis (16). This program provided guidance and knowledge on reducing the incidence of silicosis exposure. Organizations like OSHA, NIOSH, and the American Lung Association started acting and added their conferences and campaigns regarding silicosis prevention. These programs raised awareness of the hazard and brought attention to the silicosis issue, putting pressure on the government in order to develop and implement standards for silicosis in the working industries.

## **4.0 Case Histories**

### **4.1 Cases #1**

Case number one was A 39-year-old man diagnosed with silicosis (progressive massive fibrosis) and tuberculosis in April 1993 after working 22 years as a sandblaster. He had noticed a gradual increase in shortness of breath, wheezing, and discomfort from minimal exertion. In addition, tissue taken from his lungs showed extensive fibrosis. The sandblaster was first officially diagnosed with silicosis in 1993 when a coworker had developed tuberculosis, and the State health department had administered chest X-rays and skin testing to the entire crew. He was one of 20 workers who sandblasted welds during water tank construction to prepare the metal for painting. While sandblasting, he wore a charcoal filter respirator. During a 10- to 11-hour day, he spent 6 hours sandblasting (22).

### **4.2 Case #3**

In the early 1980's rising oil prices led to a production boom in the Permian Basin, and West Texas sandblasters were employed to capacity preparing pipes, tanks, and manifolds. Working conditions were extremely dusty (breathing zone air samples recorded high amounts of respirable free silica), little or no respiratory protection was used, and sand was continually recirculated until it was too fine to be no longer helpful. Although abrasive blasting with crystalline silica has been banned in most industrialized nations for several decades, its use is still

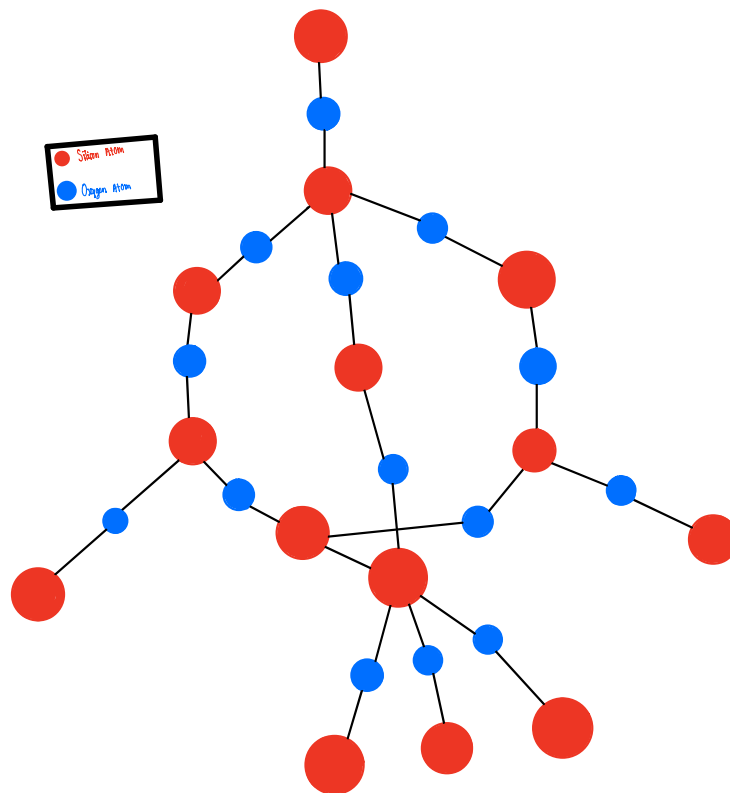
permitted in the U.S. and Canada. As a result, numerous unfortunate, heavily exposed workers have developed accelerated silicosis (an uncommon type of Silicosis developing after hefty exposure).

### **4.3 Case #6**

Case number six was a building renovation mason. He was a 55-year-old man diagnosed in 1994 with simple silicosis after working 30 years as a building renovation mason. Although a lung biopsy revealed *silicotic nodules*, he was still working as of 1995. This mason used an air-supplied respirator while sandblasting during the past 25 years. Sand (or occasionally coal slag) was the usual abrasive. The frequency of sandblasting was reported to be 12 times per year and twice per year currently. Periodically, the mason used a handheld masonry saw with no water on the blade (though he did wear a disposable particulate filter respirator) (8).

## 5.0 What is it?

Silicosis is a type of pulmonary fibrosis, a lung disease caused by breathing in tiny bits of silica, a common mineral found in sand, quartz, and many other rock types. Silicosis mainly affects workers exposed to silica dust in jobs such as construction and mining (13). Silica is the name of a group of minerals containing silicon and oxygen in a chemical combination having the general formula of silicon dioxide, *SiO<sub>2</sub>*.



**Figure 1. Silicon Dioxide (SiO<sub>2</sub>)**

Re-drawn from Nanografi Nano tech, 2022

Silica exposure over time causes scarring in the lungs, which can harm your ability to breathe. There are three known standard forms of silicosis: acute, chronic, and accelerated silicosis (12). Acute silicosis occurs after a few years of exposure to extremely high concentrations of silica dust. These afflicted individuals usually have stable health. With chronic silicosis, these individuals show symptoms after 15 to 20 years of moderate to low exposure rates. Often, a chest x-ray is needed to determine if there is lung damage. Finally, accelerated silicosis happens quicker than chronic silicosis and can be detected after 5 to 10 years of high exposure rates. Looking at the chart below, we can see the five clinically identifiable forms of silicosis. The five forms of silicosis below are more in-depth descriptions that are used in a clinical setting depending on your exposure time, symptoms, and lung functions. Here we have simple, complicated, chronic, interstitial pulmonary fibrosis, accelerated, and Acute. Mentioning only a few since a few clinical forms were previously discussed, Interstitial Pulmonary Fibrosis is when a patient experiences less than ten years of exposure that shows dyspnea and cough as their symptoms. The lungs have a restrictive change with reduced diffusion capacity in this phase. After the Interstitial Pulmonary Fibrosis phase, severity quickly increases.

**Table 1. Clinical Forms of Silicosis (Fernández Álvarez et al., 2015)**

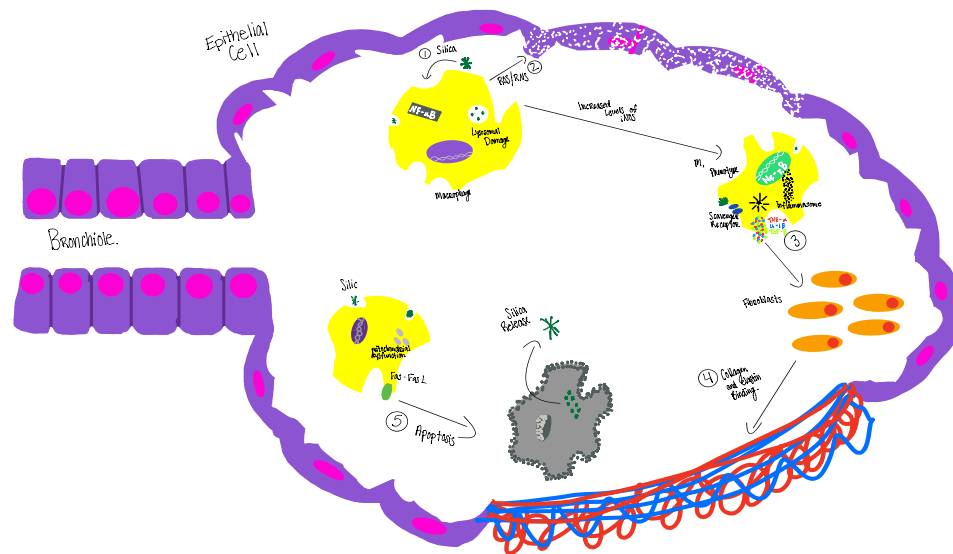
Clinical form	Time of exposure	Radiology	Symptoms	Lung function
Simple chronic	>10 years	Nodules <10 mm	None	Normal
Complicated chronic	>10 years	Masses >1 cm	Dyspnea, Cough	Obstructive or restrictive changes, variable severity
Interstitial pulmonary fibrosis	>10 years	Diffuse reticulonodular pattern	Dyspnea, Cough	Restrictive changes with reduced diffusion capacity
Accelerated	5–10 years	Rapidly progressing nodules and masses	Dyspnea, Cough	Rapidly deteriorating lung function (FVC and FEV1)
Acute	<5 years	Bilateral acinar pattern similar to alveolar proteinosis	Dyspnea	Generally restrictive changes with reduced diffusion capacity

### **5.1 Silica is not just dust!**

Silica is the most copious mineral in the Earth's Crust. Therefore, any occupations that include chipping, cutting, drilling, grinding soil, granite, or other natural material can cause exposure to silica dust. Some high-risk occupations include stone countertop fabrication (specifically engineered stone), foundry work, ceramics manufacturing, mining, and drilling (both conventional extractions and hydraulic fracturing) (21). When silica dust enters the lung, it causes inflammation, which leads to the development of scar tissue that makes breathing difficult. Often exposure occurs in respirable size particles (<10µm) of *crystalline silica dust* retained in the lungs, which are the primary *pathogenesis* of silica-related lung disease (1).

## 6.0 Silica and the Cycle of Damaged Lung Tissue

The most pathogenic particles for humans are those under the ten microns. (20). These silica particles bypass the *mucociliary defense mechanism* in the airways and reach the distal portion of the lung (2). Silicosis is composed of a *cycle of phagocytosis* and the release of particles that lead to epithelial damage, lung remodeling, and reduction of gas exchange. Lung damage caused by silica particles occurs in five main phases (3). The first is direct cytotoxicity then the generation of reactive species, then the production of cytokines and chemokines, followed by fibrosis, and then finally, cell death occurs through apoptosis (20).



**Figure 2. The Five Phases of Lung Damage**

(re-drawn from Lopes-Pacheco, *et al*, 2016)

Reactive oxygen species (ROS) and reactive nitrogen species (RNS) are highly reactive molecules. Some examples of ROS are peroxides, superoxide, and hydroxyl radicals. Some examples of RNS are nitric oxide, antioxidants, enzymes, and proteins (27).

Both species are primarily produced by the biological defense system against microbial pathogens, but sometimes mistakenly directed against other noxious agents including particulates (20). The interaction between *alveolar macrophages* and silica particles causes respiratory bursts with high consumption of oxygen, and production of ROS, which is damaged to cells in the lung (2). Nitric oxide is an essential component here because it plays a crucial role in silicosis pathogenesis. Nitric oxide is formed by converting the amino acid L-arginine to L-citrulline in the presence of Nitric Oxide Synthase (NOS) (20). This causes a reaction with superoxide forming peroxynitrite, which damages the mitochondria and the DNA (2). Macrophages are the first cells to interact with silica particles, and this interaction can activate a range of extracellular signals that lead to the polarization of these cells. The *M1 macrophages* are responsible for the antimicrobial and inflammatory responses (20). When the macrophage receptors are removed, inflammation after silica exposure increases. This calls for the recruitment of *fibroblasts* to the damaged site (3). The increased tissue damage caused by silica particles, with multiple other measures, is responsible for the *granuloma function* and lung remodeling that impairs lung functions (3). In addition, cells release chemotactic factors during apoptosis that recruit new inflammatory cells, increasing inflammation. An important note is that when macrophages undergo *apoptosis*, they release silica particles back into the lung, which leads to the constant continuation of tissue damage (3).

## 6.1 A Re-Emerging Issue

This exposure has been recently re-emerging in the United States and other high-income countries as a tenacious occupational hazard. OSHA estimates that 2.3 million U.S. workers are exposed to silica at work (1). This amount equals about 2 million in the construction industry and about 300,000 in other known industries (i.e. mining). Becoming increasingly common among young workers in the United States, these numbers reflect the high exposure to silica dust in sectors such as coal mining. Studies have shown that silicosis is predominantly present in individuals ages 18-44 and is continuously seen in young workers, according to the CDC and OSHA (3). Like the United States, Australia is also seeing an increase of cases in correlation of silica and coalminers. The figure below shows the most frequently recorded industries listed on the Death Certificates of individuals who lost their battle with silicosis. The construction industry had 118 deaths at 13.4%, with the highest deaths.

**Table 2. Silicosis: Most Frequent Recorded Industries on Death Certificate**

<b>CIC</b>	<b>Industry</b>	<b>Number of Deaths</b>	<b>Percent</b>
060	Construction	118	13.4
040	Metal mining	86	9.8
041	Coal mining	69	7.8
270	Blast furnaces, steelworks, rolling and finishing mills	51	5.8
050	Nonmetallic mining and quarrying, except fuel	48	5.5
271	Iron and steel foundries	48	5.5
262	Miscellaneous nonmetallic mineral and stone products	44	5.0
392	Not specified manufacturing industries	33	3.8
331	Machinery, except electrical, n.e.c.	23	2.6
252	Structural clay products	20	2.3
	All other industries	317	36.0
	Industry not reported	23	2.6
	<b>TOTAL</b>	<b>880</b>	<b>100.0</b>

([www.cdc.gov/niosh/docs/96-112/default.html](http://www.cdc.gov/niosh/docs/96-112/default.html). ; February 2022)

## **6.2 How it Affects Industry Workers**

Silicosis complications include tuberculosis, lung cancer, chronic bronchitis, autoimmune disorders, and the possibility of kidney disease (4). The symptoms of this re-emerging disease are late-onset and do not usually appear until many years after exposure. In the early stage of symptoms (2 years), symptoms occur as a mild cough and shortness of breath. As the lung scarring worsens, more severe symptoms such as bronchitis-like symptoms, difficulty breathing, extreme shortness of breath, and fatigue will occur (5). Studies show that because silicosis attacks the immune system, this disease puts patients in a vulnerable position, possibly developing tuberculosis.

## **7.0 Silicosis in Construction Workers**

Those in the construction industry are at some of the highest exposure rates to silica dust, and studies have shown that this industry has the highest amount of deaths due to silicosis. When working in the construction industry, day-to-day tasks may consist of demolishing concrete structures, mixing concrete, chipping, hammering, and drilling rock, sawing, hammering, drilling, and other daily tasks (13). These activities invariably cause workers to be exposed to respirable crystalline silica. Air monitoring on a construction site is complex due to the constant fluctuation of levels. The concentration of air-silica varies widely, depending on the type of tool used, whether your area is ventilated or enclosed, or whether the dusty work is constant or intermittent. Below is a table that shows pooled air monitoring from the OSHA offices in Washington, Oregon, and Chicago. The range of concentrations for these eleven commonly used construction tools is quite extensive. The large capacity makes it more difficult when trying to control the dust. The most concerning, though, is that six out of the eleven most commonly used construction tools resulted in a median air level over the Permissible Exposure Limit, but every device had been over the limit at one point in time.

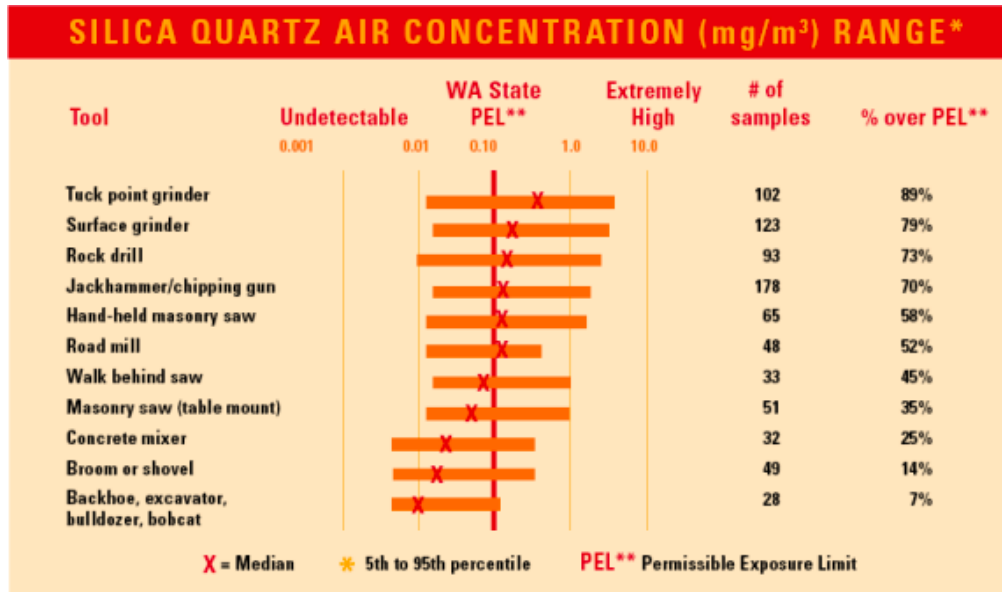


Figure 3. Silica Quartz Air Concentration

"Silicosis in Construction." ([www.lni.wa.gov/safety-health/safety-research/ongoing-projects/occupational-respiratory-disease](http://www.lni.wa.gov/safety-health/safety-research/ongoing-projects/occupational-respiratory-disease); February 2022)

## **8.0 Potential Cancer Risks**

Silicosis is an interstitial lung disease and studies have also identified lung cancer as a potential diagnosis sequela associated with occupational exposures to respirable crystalline silica. Although other cancers, such as esophageal, stomach, and skin, are possible sequelae, lung cancer is seen the most secondary to long-term silicosis (2).

### **8.1 Study Findings**

Murine models, an effective tool in the study of cancer, specifically show that chronic silicosis is associated with an increased risk of lung cancer. Studies have looked at the effect of silicosis and animals, specifically the study conducted in 2018 by Takashi Sato (4). When looking at mice and rats were exposed to silica particles by inhalation or installation, the initial inflammation induced by silicosis exposure was followed by the development of an immunosuppressive environment that leads to the increased support of lung tumor growth. Silica can influence the process of epithelial cell damage and subsequent carcinogenesis through several pathways. The study's conclusion showed that once tumors occur in silicotic lungs, the growth is enhanced by an immunosuppressive environment that protects them from immune elimination (18).

## **9.0 Preventability**

Can silicosis be prevented? Controlling exposure is currently the most effective way to avoid silicosis. One can eliminate job tasks that expose workers to respirable crystalline silica, substitute non-crystalline silica materials when possible, incorporate controls to reduce silica dust as well as administrative rules such as limiting the length of time a worker can spend around silica dust and to provide the correct types of Personal Protective Equipment, such as a respirator.

### **9.1 Work Practices that Must be Done.**

Workplaces owe it to their employees to reduce and control the exposure of silica, which can be achieved in many different ways. When it comes to controlling silica dust, the most effective option is to keep dust out of the air. Water spraying, vacuuming, or other ventilation measures can help reduce dust from getting into the air. Engineering controls can control emissions at the source. These controls consist of workplace design, equipment selection, modification of existing equipment, and ventilation. Work practices, such as safe handling and disposal of materials containing silica and adequate personal protective equipment such as eye and face protection, skin protection, and respiratory protection (17). Proper personal protective equipment consists of always wearing a mask when a high dust concentration is present, refraining from smoking, and wearing an excellent OSHA-approved respirator. Disposable filtering face respirators will not protect workers from silica exposure during sandblasting. This technique

requires adequate engineering controls with a local exhaust ventilation system and wet methods to ensure safe processes (21).

## **9.2 Prevention Programs**

Another essential practice managed in a workplace is a medical surveillance program. This program would be for all current and new employees within the plant. All employees would participate in baseline testing where each worker is accessed before a doctor or physician's first day of work. The baseline tests would consist of scans, oxygen levels, blood work, as well as the worker medical monitoring systems mentioned in section 1.2 The systems include radiographic monitoring as well and spirometric monitoring. Radiographic monitoring primarily used for pneumoconiosis, but is becoming a widely accepted practice in monitoring different forms of occupational respiratory diseases. This test is used to detect early signs of lung damage. Spirometric testing is often used in the United States to monitor workers for asthma (21). These checks would continue yearly or biyearly to continue check-ups. These check-ups would be a detection technique to find abnormalities early on. These check-ups will also allow the doctors and physicians to compare if abnormalities are consistent with the health effects of silica exposure. Worker's involvement in prevention measures and mechanisms is a critical aspect of preventing silicosis within the workplace. Some ways for the workers to get involved can consist of committees run by the site workers. For example, a safety committee can be implemented, including shop employees only. This committee can run health and safety inspections in the workplace, hazard assessments of dust, assist in the preparation of work practices to minimize dust exposure, and most importantly, training of all current and new workers, so it would be known

that all employees are aware of the safety mechanisms and requirements that are to be followed in the workplace.

### **9.3 Prevention Strategies**

Referencing the table below, there are three prevention techniques. Primary prevention aims to prevent the disease before it ever occurs. This would be to monitor respirable dust levels and recommend personal protection measures in your workplace. Then we have secondary prevention. Secondary prevention aims to reduce the impact of the disease. This is done by detecting and treating silicosis as soon as possible. This will halt or slow down the progression of the disease. In a workplace, this will happen by monitoring exposed workers, monitoring for tuberculosis infections, and the cessation of smoking. Finally, we have tertiary prevention. The prevention technique aims to soften the impact of an ongoing illness that has lasting effects. In a workplace, this prevention method would focus on avoiding exposure to dust inhalation, reporting cases to OSHA, monitoring for tuberculosis infection, and concentrating on the treatment of airflow limitation and respiratory failure. These prevention strategies are essential because, combined; they aim to prevent the onset of disease through risk reduction and reduce the complications of the disease from the start.

**Table 3. Silicosis Prevention**

Primary prevention	Monitor levels of respirable dust Recommend personal protection measures
Secondary prevention	Monitor exposed workers Smoking cessation Monitoring for tuberculosis infection
Tertiary prevention	Avoid exposure to dust inhalation Report cases, recommend occupational disease assessment Monitoring for tuberculosis infection Treatment of airflow limitation and respiratory failure

(Fernández Álvarez *et al.*, 2015)

## **10.0 Treatment**

Despite the fair uproar in response to silicosis and its preventability, little has been achieved in treatment development. Research in silicosis is happening at a prolonged rate compared to other chronic lung diseases. Only two registered clinical trials have been done on silicosis treatment options in the past ten years (25). There is no exact cure for silicosis, but management/treatment of symptoms is available. These techniques need to begin at the first onset of symptoms. These options include using a bronchodilator to help decrease inflammation in your air tubes, immediately quitting smoking, supplemental oxygen, and pulmonary rehabilitation (9). These treatment techniques are focused on slowing down the progression of the disease and relieving symptoms. First, your doctor will take a medical history, asking a series of questions in relation to your job, hobbies, and other activities where exposure may have occurred. A physical exam will then be given, including chest x-rays, chest C.T. scans, T.B. tests, and blood tests. A chest x-ray and C.T. scan will give the doctors a better picture of your lungs, so they can assess how much damage has occurred. A T.B. test is given because silica exposed workers, with or without silicosis, are at an increased risk for tuberculosis. After the exams and tests are complete, a treatment plan of action will be implemented (26).

## **10.1 Herbal Alkaloid for Treatment**

One drug that has been specifically tested to treat silicosis is the herbal alkaloid tetrandrine. The drug is historically known for treating pneumoconiosis in Chinese medicine, and its therapeutic use for silicosis was approved by the State Drug Administration of China (10). In addition, studies have used this drug as a therapeutic to treat asthma, where it is said to work as a bronchodilator and mild expectorant (29).

## **10.2 Antibiotics**

Infections are present as co-morbidities in virtually all silicosis cases so antibiotics can be used at times, but eliminating your exposure is the best treatment option (29). There is a form of medication called anti-fibrotic agents. This treatment method has shown in clinical trials that there is a potential to slow down the rate of fibrosis or scarring in the lungs. With this being a major symptom from silicosis, clinical trials have started with individuals with the diagnosis. So far, two antifibrotic drugs have been approved for the treatment of fibrosis in the lungs, Nintedanib (kinase inhibitor) and Pirfenidone (29). These two treatments are known as antifibrotic drugs because they have shown in clinical trials to slow down the rate of fibrosis in the lungs (30).

Both of these drugs are known to down-regulate the growth factors (such as lung scarring) that are implicated in the development and progression of fibrosis. Currently, there is a trial called the INBUILD trial. Taking part in 15 different countries, this trial is in the third phase for over six-hundred patients with progressive fibrosing interstitial lung disease. At the two year follow up,

there was a significant decrease in the annual rate of decline in lung function and with the treatment of Nintedanib, lung function decline slowed by fifty-seven percent (30).

### **10.3 Allografts**

As a last resort, lung transplants are suggested for some silicosis patients with no more pharmacological options, but this option is extremely rare (29). Looking at a recent study that took place between September 2000 and February 2018, twelve research scientists and doctors strategically looked at six patients who underwent lung transplantation due to silicosis at two different transplant centers in Sao Paulo City. This procedure is still rarely performed due to complications and technical difficulties. This is due to the presence of calcified mediastinal and hilar lymph nodes hindering the correct visualization and separation of structures, which increases the risk of bleeding during the lung removal process. This study came to a close in 2020, with the results showing that lung transplantation for selected patients with end-stage silicosis could be effective, with a significant increase in the median survival of 3.35 years (29).

### **10.4 Cell-Based Therapy**

Cell-based therapies have the advantage of modulating inflammation, which is why this method could be a good option for treating silicosis (20). This method allows for the advantage of modulating inflammation and affecting the remodeling process without presenting toxicity or

immunosuppression (20), which is why this therapy method is a good technique for the treatment approach for fibrotic lung diseases. In 1981, embryonic stem cells were described by Evans and Kaufman as *pluripotent* cells derived from the internal mass of a *murine embryo*, changing the paradigm for the potential of stem cells (20). Stem cells were then found in almost all adult tissue, allowing cell transplantation to begin as a possible treatment for multiple diseases. Cell transplantation exerted beneficial effects in many different models of diseases, including silicosis.

## **11.0 Actions that Need to be Taken**

Like North America, Europe also believed that silicosis is a disease of the past, but studies show that around 5 million workers in the European Union are regularly exposed to respirable crystalline silica. In comparison, 1.7 million North American workers are exposed to respirable crystalline silica in various industries—the most being in construction, sandblasting, and mining. At the beginning of 1990, more than 3 million European workers were exposed to crystalline silica while working in the stone finishing industry in Spain (23). Focusing in on those with lower working years in the industry amongst the 3 million, forty-six men with a median age of 33 years old and 11 years working in countertops manufacturing were diagnosed with silicosis. In the early 2000s, the Health and Safety Commission of Europe (HSE) set a reduced Workplace Exposure Limit (WEL) at  $0.1\text{mg}/\text{m}^3$  as an 8-hour time average in Great Britain (24). As a result, their European counterparts came together with the European Union to draft practice guidelines to protect their industry workers from silica. These guidelines are reviewed every two years to update the policies regularly. The World Health Organization (WHO) and the International Labor Organization (ILO) have begun a campaign to end silicosis by 2030 worldwide (31).

Early prevention techniques need to be implemented by the workplaces to protect their employees. These early prevention techniques include monitoring system that alerts employees when levels of silica dust in the air is too high in their work area. Another essential practice managed in a workplace is a medical surveillance program. Like discussed in section 8.2, this program would be for all current and new employees within the plant. All employees would participate in baseline testing where each worker is accessed before a doctor or physician's first

day of work. These checks would continue yearly or biyearly to continue check-ups. These check-ups would be a detection technique to find abnormalities early into the diagnosis.

Training needs to be given to workers on the effects of silicosis and how it can be prevented. Silicosis prevention training should be given to all new employees before their first day on the floor. This training is just as important as 3PC ladder training, the proper PPE training, etc. The training will consist of different areas such as why silicosis is dangerous, the effects it can cause on your body, what can happen when you have a silicosis diagnosis, etc.

Another early prevention technique is to have strict personal protection equipment rules within the workplace need to be put into place. Just like proper gloves for a certain job, proper eye protection when power washing, workers need proper face coverings and respiratory use when needed. This is one of the most proper forms of prevention of silicosis because you are keeping yourself safe. Managers and supervisors need to make sure they are forcing this aspect and consequences for not following the rules on all levels.

More scientific studies need to be done on silicosis. Scientists need to look at the longevity of the diagnosis. When individuals are normally seeing the onset of symptoms. How severe the symptoms are, etc.? Studies need to look at the ways to cure or reduce the effects of silicosis. Science is always evolving, one study every so many years is not helpful at this point, we need to have constant studies, occurring so many years in order to find a cure but to have these studies, science needs the funding.

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