

The Importance of Using Personal Protective Equipment (PPE) and Collective Protective Equipment (CPE) for Workers Exposed to Silica: An Updated Literature Review

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Abstract— This article aims to identify preventive measures for workers involved in mining activities, particularly those exposed to silica dust and at risk of developing silicosis, an occupational pulmonary disease that is progressive and irreversible. Mining environments contain various substances or products that pose health risks, including cement, rubber, wood, petroleum derivatives, epoxy resins, chromium, and nickel. Continuous exposure to these agents requires the implementation of control strategies, including respiratory protection measures, environmental monitoring, and occupational health actions, aiming to minimize occupational risks and prevent the onset of pneumoconioses. The role of the Specialized Service in Safety Engineering and Occupational Medicine (SESMT) is essential for risk identification and classification, as well as for defining the appropriate types of personal protective equipment (PPE) required for each job and sector. Periodic workplace inspections and health monitoring allow functional adjustments whenever changes are detected that may compromise workers' physical integrity. These measures also include continuous education and training on proper PPE use, emphasizing the importance of each device as a protective tool: "any device or product, for individual use by the worker, intended to protect against risks likely to threaten work safety and health" (BRAZIL, 1978). The effectiveness of preventive measures depends on multidisciplinary work involving safety, engineering, and occupational health professionals. Integration among these sectors not only reduces risks but also enables the implementation of continuous, evidence-based prevention actions. According to studies, applying knowledge from safety engineering and occupational medicine to all components of the work environment, including machinery, equipment, and processes, contributes to the elimination or reduction of health risks for workers (HAAG, 2001). The methodology adopted in this study consisted of a bibliographic review, including the analysis of scientific articles, specialized journals, technical literature, and regulatory standards (NR), aiming to understand occupational silica exposure, prevention mechanisms, and the role of occupational health and safety policies. This approach allowed

the identification of effective strategies for silicosis prevention, highlighting the importance of inspection, periodic health monitoring, and proper PPE training. In conclusion, reducing the incidence of silicosis depends on a combination of engineering controls, individual protection, periodic medical follow-up, and worker awareness. Integration among SESMT, health professionals, and industrial managers is essential for implementing consistent and sustainable preventive actions, ensuring not only the protection of workers' health but also the maintenance of productivity and safety in mining environments.

I. INTRODUCTION

Silicosis is a chronic, irreversible, and progressive occupational lung disease, classified as a pneumoconiosis caused by the inhalation of respirable crystalline silica (SLC) particles. This pathology is characterized by the development of a persistent inflammatory process, granuloma formation, and subsequent pulmonary fibrosis, resulting in functional impairment and a significant reduction in the quality of life of the exposed worker (RIBEIRO et al., 2023).

Despite advances in occupational health, silicosis remains a serious public health problem, especially in developing countries, where mining, construction, and, more recently, the manufacture of artificial stone countertops represent significant sources of exposure (SBPT, FUNDAÇÃO JORGE DUPRAT FIGUEIREDO, 2024). In Brazil, recent outbreaks have drawn the attention of health authorities, highlighting the persistence of shortcomings in prevention and workplace monitoring strategies.

From a pathophysiological point of view, silica inhalation triggers the activation of alveolar macrophages, which, upon phagocytizing the particles, release inflammatory and pro-fibrotic mediators, such as tumor necrosis factor alpha (TNF- α) and interleukins. This inflammatory cascade results in the deposition of collagen fibers and thickening of the lung parenchyma, with a consequent reduction in ventilatory capacity (LOMBARDI et al., 2023).

Recent literature has highlighted the importance of inflammatory biomarkers in the early detection of silicosis, such as lactate dehydrogenase (LDH) and soluble TNF receptors (sTNFR_{II}), which show a direct correlation with the clinical and radiological severity of the disease (RIBEIRO et al., 2023). Furthermore, genetic studies demonstrate that individual susceptibility is a determining factor in the evolution of silicosis, since polymorphisms in genes related to the inflammatory response and oxidative stress directly influence clinical severity, even among individuals subjected to similar exposures (COSTA et al., 2024).

The clinical forms of silicosis include chronic silicosis, which develops after decades of continuous exposure, accelerated silicosis, associated with intense exposures over a period of 5 to 10 years, and acute silicosis, also known as silicoproteinosis, which develops within a few months to years and progresses rapidly, often culminating in severe respiratory failure (MSD MANUAL, 2024). All these forms share the common characteristic of being incurable, with prevention being the only effective way to reduce incidence.

Recent cases of silicosis among workers in the artificial stone industry have prompted the publication of warnings by the Brazilian Society of Pulmonology and Phthisiology and Fundacentro, which highlighted the severity of the disease and the historical negligence in collective and individual protection measures (SBPT, FUNDAÇÃO JORGE DUPRAT FIGUEIREDO, 2024). Furthermore, accounts from patients and healthcare professionals have been presented in documentaries that expose the reality of the industry and its social and human impacts.

The epidemiological relevance of silicosis in Brazil is evidenced by notifications concentrated in mining regions, such as Minas Gerais, and in ornamental rock processing centers, such as Espírito Santo. Recent data indicate that the lack of continuous surveillance and deficiencies in occupational monitoring contribute to late diagnosis, when the disease is already in an advanced and irreversible stage (BEZERRA et al., 2022).

Given this scenario, silicosis is not only a health problem, but also a social, legal, and economic challenge. Affected workers suffer severe functional limitations, reduced work capacity, and increased dependence on health and social security systems. Therefore, a thorough understanding of its pathophysiological mechanisms, contemporary epidemiology, and prevention strategies is fundamental to reducing the impact of the disease.

In this context, the present research aims to present a review on silicosis, highlighting its clinical, pathophysiological, genetic, and epidemiological aspects, based on recent studies, seeking to emphasize the importance of surveillance and prevention as the main strategies in addressing this occupational pathology.

Silicosis is an occupational pneumoconiosis caused by the inhalation of dust containing crystalline silica, characterized as an irreversible inflammatory and fibrosing disease with variable progression. Despite being widely known, it remains a serious global public health problem, impacting millions of exposed workers in different industrial sectors (GBD, 2023).

It is estimated that approximately 230 million people are occupationally exposed to respirable silica worldwide, with more than 30 million in China and India alone, revealing the epidemiological magnitude of the disease (DISCOVER PUBLIC HEALTH, 2025). Data from the Global Burden of Disease indicate that, between 1990 and 2019, the absolute number of cases increased by 64.6%, although standardized incidence and mortality rates have decreased in some countries (GBD, 2023).

In Brazil, silicosis is considered the most prevalent pneumoconiosis, mainly in mining, ornamental stone processing, and civil construction regions (SOUZA, MONTEIRO, 2025). An epidemiological study indicates a prevalence of 37% among workers in semi-precious stone mining, associated with risk factors such as inadequate ventilation and dry drilling (ALGRANTI et al., 2021).

Regarding mortality, analysis of the last few decades revealed an increasing trend until the mid-2000s, followed by a decline, especially in areas with greater enforcement of workplace safety standards (ALGRANTI et al., 2021). Even so, recent estimates indicate that, in 2018, approximately 3 million formal Brazilian workers were exposed to silica, representing more than 1% of the economically active population (JBP, 2025).

The impacts of silicosis transcend the clinical sphere, affecting socioeconomic dimensions. The disease frequently affects individuals of working age, reducing their ability to work and increasing costs related to medical and social security care. Furthermore, its irreversibility reinforces the importance of epidemiological surveillance and prevention as central strategies to mitigate its effects (DISCOVER PUBLIC HEALTH, 2025).

Thus, the epidemiology of silicosis reveals a persistent condition, with significant growth in the absolute number of cases, especially in developing countries. In Brazil, despite a relative reduction in mortality in some periods, the high prevalence and widespread occupational exposure highlight the disease's continued impact. In this sense, public policies for control and monitoring are fundamental to reducing the clinical and social burden of silicosis.

Silica, or silicon dioxide, is a natural compound composed of two chemical elements in the Earth's crust: oxygen and silicon. It is found in nature in amorphous and crystalline forms, which, when combined with metals and

oxides, give rise to silicates such as talc, feldspar, kaolin, and mica. The amorphous form, although not inert, is less toxic than the crystalline form, and is found in vitrified volcanic rocks, unheated diatomaceous earth, silica gel, synthetic glass, and glass wool. (TERRA FILHO, 2006)

Inhalation of silica dust is associated with the occurrence of silicosis, an occupational chronic obstructive pulmonary disease, lung cancer, and diffuse interstitial fibronodular lung disease, caused by the inhalation of crystalline silica. It is the leading cause of disability among occupational respiratory diseases. (SANTOS, 2010)

Known since Antiquity, it was Visconti, in 1870, who first applied the term silicosis, but it had already been described in mummies from ancient Egypt and Greece. Hippocrates also described it when analyzing respiratory difficulties in metal diggers, and it was described in the 16th century in Bohemian miners and in stonecutters in the 18th century. (SANTOS, 2010).

How can we reduce accidents and occupational illnesses among workers exposed to silica?

There are recorded instances, dating back approximately two thousand years, of workers using masks to protect themselves from silica dust, which was considered hazardous. It was observed that the mixture of dust with air caused lung damage.

Thus, humidification and ventilation inside mines reduce the amount of dust in the air, recognized as an agent of pulmonary diseases, and coughing and dyspnea are common in certain mines.

Given this context, the following objectives were proposed:

- To present a literature review on the importance of using individual and collective protective equipment, the profile of the exposed worker, to determine if silicosis occurs even with the use of PPE, to identify shortcomings in accident prevention measures, to identify preventive measures for silica workers located in a hazardous environment.

The rationale for developing this work is based on providing more information about silicosis, an occupational lung disease in mining workers. The proposed objective and methodology adopted were a bibliographic research approach, the research sources for this work were journals, articles, specialized literature in the field, and regulatory standards (NR).

II. MATERIALS AND METHODS

For the development of this study, bibliographic research was chosen, which encompasses secondary sources and bibliography already made public in relation to

the study topic, from individual publications, bulletins, newspapers, magazines, books, research, monographs, theses, cartographic material, among others, to even oral means of communication: radio, magnetic tape and audiovisual recordings, films and television.

The purpose of the broad scope of the selected sources was to update readers interested in this subject and to familiarize them with the various types of individual and collective protective equipment used in the treatment of silicosis.

The results were based on questions raised by the various sources researched.

III. DEVELOPMENT

Silica

Silica, composed of silicon dioxide (SiO_2), is an abundant mineral in the Earth's crust and is present in rocks, sands, and clays, being widely used in industrial processes such as ceramics, construction, cosmetics, and pharmaceuticals (INCA, 2022). The respirable crystalline form, when inhaled, represents a significant occupational risk by triggering serious respiratory diseases.

Globally, it is estimated that approximately 230 million workers are exposed to respirable silica dust, with 34 million of these working in China and India, the countries with the highest prevalence, reinforcing the epidemiological relevance of silica as an occupational risk (DISCOVER PUBLIC HEALTH, 2025). Studies from the Global Burden of Disease highlight that silicosis represents 90% of pneumoconiosis cases worldwide, with increasing trends in terms of the absolute burden of the disease (incidence and DALYs), although some standardized rates may show a decline (GBD, 2023).

In Brazil, occupational exposure to silica is significant and concentrated in sectors such as civil construction, stone extraction, non-metallic minerals, and metallurgy. In 2001, 5.6% of Brazilian workers were classified as "definitely exposed" to silica, a percentage higher than that observed in European countries (REIS, 2008). The mining of semi-precious stones, especially in cooperatives in the South of the country, showed a prevalence of silicosis of up to 37% among active workers (ALGRANTI et al., 2021).

Furthermore, recent exposures in the artificial stone industry have generated global concerns, with an increase in cases, warnings from health authorities, and evidence of high concentrations of silica dust emitted during cutting and polishing (FUNDACENTRO, 2024). Silica also presents adverse effects that go beyond silicosis, including lung cancer, autoimmune diseases, and tuberculosis, making it a

multifaceted agent of concern in occupational health (INCA, 2022).

Furthermore, recent studies in China have estimated that, over 30 years, the cumulative incidence of silicosis can reach 50–57% among workers exposed to total and respirable dust (JMIR PUBLIC HEALTH, 2024). This evidence highlights the urgent need for more effective preventive measures and regulatory policies to control silica exposure.

Therefore, silica, although ubiquitous in natural resources and industrial products, represents a serious and persistent occupational risk. Its widespread presence requires continuous vigilance, strict regulation, and the adoption of environmental control technologies. Recognizing its systemic impacts and implementing preventive strategies are imperative to reduce this burden on workers and health systems.

Chronicle

The chronic form is the most common, known as the simple nodular form, and occurs after many years of exposure to relatively low levels of dust. According to ZISKIND, 1976, it can last from ten to twenty years at very low dust levels. It is characterized by the presence of small, scattered nodules, less than one centimeter in diameter, which are prevalent in the upper thirds of the lungs. Histology shows nodules with concentric layers of collagen and the presence of light-polarized structures. As the disease progresses, the nodules may coalesce, forming larger conglomerates and replacing the lung parenchyma with collagenous fibrosis. Patients are usually asymptomatic or present with symptoms that are preceded by radiological changes. (BRUNNER & SUDDARTH, 1998)

Dyspnea on exertion is the main symptom, and the physical examination usually does not show significant changes in the respiratory system. This type of silicosis can be observed in the ceramics industry. (BRUNNER & SUDDARTH, 1998)

Accelerated

Accelerated or subacute silicosis is a clinical term applied to a condition that has an intermediate rate of progression between acute silicosis and classic chronic nodular disease, requiring, on average, five to ten years of dust exposure for the appearance of radiological changes. According to ZISKIND, 1976, the symptoms are similar to those of the chronic form, but its development occurs in earlier stages, with an intense interstitial inflammatory component and cellular desquamation in the alveoli. (CANEIRO, 2003)

Respiratory symptoms are usually early and limiting, with a high potential for progression to the complicated form of the disease, such as the formation of conglomerates and massive fibrosis, this silicosis is observed in well diggers. (BRUNNER & SUDDARTH, 1998)

Acute

The acute form of the disease is very rare and occurs in workers exposed to exceptionally high concentrations of fine, recently fractured crystalline silica particles, as occurs in sandblasting and stone grinding. (FERREIRA, 1999)

Dyspnea can be debilitating, potentially leading to death from respiratory failure, accompanied by a dry cough and compromised general condition. Physical examination reveals diffuse crackles, and the radiological pattern differs significantly from other forms, characterized by diffuse and progressive alveolar infiltrations, often accompanied by poorly defined nodules. (HAAG, 2001)

Diagnosis

Diagnosing silicosis requires a rigorous clinical approach, especially in occupational environments with exposure to respirable crystalline silica (CLS), such as mining, construction, and artificial rock industries. The central focus of the diagnosis is a detailed occupational history, which should include the nature, intensity, and duration of exposure, as well as the use of protective measures (MSD, 2025).

The physical examination and symptoms, even if nonspecific, such as dyspnea, dry cough, and fatigue, should be associated with appropriate diagnostic procedures to avoid late diagnoses, which are common in Brazilian clinical practice (Fundacentro, 2024).

Chest radiography remains a primary screening tool, as it combines images with occupational history in most diagnoses. Observed radiological patterns include the presence of nodules and linear shadows in the middle and upper zones, or, in cases of complicated silicosis, fibrous conglomerates migrating towards the pulmonary hilum (Brazilian Radiology, 2025).

When radiography is inconclusive or in cases considered "borderline," high-resolution computed tomography (HRCT) is indicated. A study with former gold miners used clinical and environmental criteria to define a flowchart that guides the indication for HRCT, highlighting its usefulness in the early detection and silent severity of the disease (UFMG, 2024).

The correlation between radiological and anatomopathological findings reinforces the role of HRCT. Patterns such as confluent nodules or conglomerate masses,

especially in the upper posterior thirds of the lungs, have been described as typical of silicosis.

Spirometry and pulmonary function tests, including diffusive carbon monoxide capacity (DLCO), provide important functional data. Restrictive changes or reduced gas exchange confirm the functional impact of the disease and help differentiate silicosis from other lung diseases (MSD, 2025).

The application of artificial intelligence (AI) technologies in diagnostic imaging is a promising frontier. A model based on graphical transformers combined with neural networks achieved very high accuracy in distinguishing between silicosis and pneumonia, with an F1 score of 0.9749 and an AUC greater than 0.99, in a recent deep learning study (Bui et al., 2024).

Furthermore, South Africa plans to incorporate AI for screening and diagnosing silicosis and tuberculosis in miners, aligning with WHO recommendations and recognizing the role of radiography as a basis, but expanding its efficiency through technology (South Africa, 2024).

In general, the ideal diagnosis of silicosis should combine: occupational history, suggestive clinical symptoms, radiography as an initial examination, HRCT for borderline cases, functional tests to assess severity, and, if available, access to AI applied to radiology for greater diagnostic accuracy.

Finally, mandatory notification mechanisms and active surveillance are essential. Early identification and establishment of causal links enable more successful preventive interventions, interrupting chains of exposure and contributing to public health strategies (Fundacentro, 2024).

The diagnosis of silicosis is made using chest radiography, along with a coherent clinical and occupational history. However, other procedures are also necessary. (FUNDACENTRO, 2011)

Lung biopsy is authorized in the presence of radiological changes with a lack of occupational history data suggesting an association. In these cases, it can contribute to the diagnosis of another disease, confirm an atypical presentation (e.g., diffuse, non-granulomatous fibrosis), or even differentiate it from chronic beryllium disease, whose etiological diagnosis has implications for treatment. (TERRA, 2006)

Simple chest radiography remains the highest quality and most effective instrument for regular and repeated monitoring of exposed workers, given its low cost and low radiation dose. (OCCUPATIONAL SAFETY

AND HEALTH, 2002)

According to the new edition of the International Classification of Radiographs of Pneumoconiosis of the International Labour Organization, 2000 revision, with minor modifications compared to the 1980 revision, the importance of this examination in medical control programs for exposed populations is ratified. Furthermore, an international investigation into the use of digital chest radiography is underway, and there is consensus among experts in the field that high-resolution computed tomography of the chest, despite its greater sensitivity in some situations, should not become a monitoring examination, precisely because it has low competitiveness in the two aspects mentioned above: cost and radiation dose.

Control Measures

Monitoring dust production in the workplace can help prevent silicosis. When this cannot be controlled, as might be the case in the sandblasting industry, workers should wear masks that provide clean outside air or that completely filter out the particles. This protection may not be available to all workers in a dusty area (e.g., painters and welders), and in that case, abrasives other than sand should be used whenever possible. According to SITICECOM, workers exposed to silica dust should have regular chest x-rays, every six months for those working with sandblasting and every two to five years for the rest, so that any problems can be detected as early as possible. If the x-ray diagnoses silicosis, the doctor will advise the worker to avoid constant exposure to silica. Basically, the necessary prevention includes:

Personal Protective Equipment - PPE

Personal Protective Equipment (PPE) consists of essential devices for protecting the health and physical integrity of workers, especially in work environments that present occupational risks. According to Regulatory Standard NR-6 of the Ministry of Labor and Employment, PPE is considered to be any device for individual use, manufactured domestically or abroad, intended to protect the health and physical integrity of the worker, and which has a Certificate of Approval (CA) issued by the competent authority.

The effectiveness of PPE is directly related to its correct use and suitability to the type of risk present in the work environment. Studies indicate that adherence to the use of PPE can be influenced by factors such as comfort, training, and worker awareness. For example, research conducted by Silva et al. (2024) points out that the lack of adequate training is one of the main factors contributing to the non-use of PPE among healthcare professionals.

Furthermore, technological advancements have enabled the development of more efficient and comfortable PPE. Innovations such as thermal sensors and remote monitoring systems have been incorporated into PPE, aiming to increase the safety and well-being of workers. A recent study by Barros et al. (2024) presents the development of a low-cost thermal imaging sensor for industrial safety, applicable in Industry 5.0 and collaborative robotics, with high precision in detecting human presence.

In Brazil, the inspection and regulation of PPE (Personal Protective Equipment) are the responsibility of the Ministry of Labor and Employment, which establishes standards and procedures for the evaluation, certification, and commercialization of these devices. Ordinance No. 11,347, of May 6, 2020, establishes the procedures and technical requirements for the evaluation of PPE and the issuance, renewal, or alteration of the Certificate of Approval (CA), aiming to guarantee the quality and safety of products available on the market.

In summary, PPE plays a crucial role in preventing accidents and occupational diseases. Its effectiveness depends not only on the technical quality of the devices, but also on the awareness, training, and commitment of workers and employers to safety practices in the workplace.

Personal protective equipment (PPE) is mandatory in work situations where occupational hazards are not fully controlled at the source of generation and transmission.

Personal protective equipment (PPE) must be provided free of charge by the company and be certified by the competent body responsible for certifying this type of equipment, as stipulated in occupational safety and health legislation.

Respiratory protective equipment (RPE) must be used by workers in the ceramic tile manufacturing process until engineering and general measures are sufficient to keep dust concentrations in the work environment below the action level (AL), which is defined as half the recommended Occupational Exposure Limit (OEL), and should be mandatory in maintenance activities.

The filters for respiratory protection equipment (RPE) must be specified according to the characteristics of the dust, considering the size, composition, and toxicity of the particles and the concentrations present in the work environment (Respiratory Protection Program, FUNDACENTRO). For dusts containing crystalline silica, the following categories may be indicated, according to these characteristics:

- Full-face respirator with P2 or P3 filter,
- Half-facepiece respirator with P2 or P3 filter,

- PFF2 or PFF3 filtering half-facepiece respirator (disposable mask).

The prescription and use of respiratory protection equipment must meet all the requirements of the Respiratory Protection Program (RPP), regulated by legal standards.

Personal Hygiene

In addition to using respiratory protection equipment, workers should be instructed and provided with the means to maintain personal hygiene and protect themselves from secondary sources of dust exposure, with measures such as:

- Wear work clothes preferably provided and laundered by the company,
- Separate work clothes from everyday clothes. To do this, the company must have changing rooms with double lockers for each worker,
- Do not use compressed air to clean clothes, as this procedure, in addition to exposing you to dust, poses other health risks.

Wash your hands, arms, and face before eating,

- to eat in an appropriate location separate from the production area,
- No smoking, preferably. If the worker is a smoker, they should smoke in a designated area, outside the production area,
- Do not wear a beard or mustache when using respiratory protection equipment.

Collective Protective Equipment - CPEs

What are PPEs? They are equipment installed in the workplace, which can be fixed or mobile, that serve to preserve the physical integrity and health of one or more workers at the same time and are used to prevent and/or minimize accidents.

Workplace Cleaning

Workplace cleaning should be done regularly, considering all areas where people circulate, including corridors, platforms, stairs, workshops, and rooms, as well as all process installations such as machinery and equipment, structures, and piping that may accumulate dust. Temporary or permanent storage areas should also be considered. (SITICECOM)

As a primary standard for cleaning production areas, it is essential that the design of the central industrial ventilation system considers its use for dust extraction during cleaning processes, through connection points for flexible hoses to the ducts, especially in press and mill areas and along enameling lines.

To vacuum up large spills of powdered material, ducted systems must be specifically designed for this purpose, in order to avoid loss of effectiveness in the central ventilation system.

In areas where forklifts and workers circulate around production lines, cleaning should preferably be done with self-propelled exhaust and/or floor washing carts. In situations where wet cleaning or exhaust methods are not technically feasible, other cleaning and collection resources, such as squeegees, shovels, and transport containers, should be used to generate the least possible dust dispersion. The use of sawdust, with biodegradable oil or another product for anointing the sawdust and deposited dust, must consider the proper disposal of waste and the risks it may pose to workers handling this waste and the cleaning products used, as well as its potential damage to the natural environment.

In locations where wet cleaning methods are used, ensure that electrical installations are properly protected from contact with water.

Equipment Maintenance

Maintenance operations may present special risk conditions, and all control measures should be adopted to minimize dust generation and worker exposure. The use of respiratory protection should be mandatory in situations where dust generation cannot be adequately controlled at its source.

Periodic checks and maintenance should be carried out on process equipment according to the instructions of its manufacturers and suppliers to ensure efficient operation, especially of enclosure and industrial ventilation systems.

Signaling

Workplace signage should be provided using warning and informational posters to inform workers about the risks present in the processes, the effects of exposure to these risks, and to guide them on preventive measures.

Warning signs can be used in areas with silica-containing dust.

In addition to warning posters about the risks present in work environments, posters with content that provides guidance, in particular, on the control measures to be observed to avoid the generation of and exposure to dust are recommended.

IV. FINAL CONSIDERATIONS

Silicosis remains one of the most relevant occupational pneumoconioses worldwide, caused by the prolonged inhalation of respirable crystalline silica particles. Recent studies show that occupational exposure remains significant

in sectors such as mining, construction, artificial rock industry, and metallurgy. Epidemiological data indicate that, even with labor regulations and preventive measures, there are still emerging cases among young workers, highlighting the need for continuous and rigorous monitoring of working conditions.

International reports indicate that the disease burden attributed to silicosis remains high, especially in developing countries where industrial safety practices may be insufficient. The prevalence of silicosis and the increase in associated morbidity reinforce the importance of integrated prevention strategies, including the correct use of personal protective equipment, the adequacy of industrial processes, and public occupational health policies.

Imaging studies are considered essential for the early diagnosis of silicosis, allowing the identification of pulmonary changes before the onset of severe clinical manifestations. Chest radiography remains the most widely used screening tool, while high-resolution computed tomography has demonstrated greater sensitivity in detecting nodules and early fibrosis. Recent research also indicates that the application of artificial intelligence in imaging exams can significantly increase diagnostic accuracy, allowing the differentiation of silicosis from other interstitial lung diseases.

Pulmonary function should be monitored periodically, as restrictive changes and decreased pulmonary diffusion reflect disease progression and functional impairment in patients. Clinical trials and systematic reviews highlight that the association between inflammatory biomarkers and genetic alterations can contribute to the assessment of individual risk and susceptibility to the disease, paving the way for personalized approaches to prevention and clinical follow-up.

Ongoing education and training for workers exposed to silica are fundamental to ensuring adherence to preventive measures. The implementation of occupational health programs, coupled with periodic inspections and safety audits, has demonstrated a reduction in the incidence of new cases. Furthermore, the systematic registration and reporting of cases allows for the construction of robust epidemiological databases, essential for trend analysis and the formulation of effective public policies.

Despite advances in understanding the pathophysiology of silicosis, significant gaps remain regarding the mechanisms that determine disease progression and the interaction between genetic, immunological, and environmental factors. Experimental studies suggest that silica particles can induce chronic inflammatory responses, leading to irreversible pulmonary fibrosis, but more research is needed

to develop targeted therapies that can slow or halt this process.

Silicosis prevention should be considered a public health priority, taking into account not only individual clinical impacts but also the social and economic repercussions resulting from work disabilities and premature mortality. Integrated strategies combining process engineering, environmental control, the use of PPE, and periodic medical surveillance are fundamental to reducing occupational risk and promoting safe work environments.

In conclusion, silicosis remains a significant challenge to occupational health, requiring ongoing efforts in prevention, early diagnosis, and clinical follow-up. A comprehensive understanding of risk factors, coupled with the implementation of effective public policies and technological innovation, is essential to reduce the incidence of the disease and minimize its impacts on workers and health systems. Recent studies reaffirm that the combination of preventive measures, education, and rigorous monitoring constitutes the most effective strategy to address this pneumoconiosis and promote occupational health and safety in a sustainable manner.

This study, based on bibliographic research, found that there is no curative treatment for silicosis, and prevention is of great importance. It is recommended that employees exposed to this risk make mandatory use of PPE (Personal Protective Equipment), as per NR 22 (Brazilian Regulatory Standard 22).

Effective standards and controls are necessary for this to happen, ventilation and humidification processes must be adequate and tested periodically by determining the environmental concentration of harmful agents.

Given the possibility of contact with highly toxic substances, accident prevention must be rigorous, occupational medicine must always be concerned, and facilities for immediate medical care must be provided.

When it is not possible to reduce pollutants, sources of air from outside the work environment should be provided, replacing a potentially harmful substance with another that is harmless to the established occupational lung disease.

Moving the worker out of an environment exposed to silica may help slow the progression of the disease.

According to RUESCAS (2000), "there is no curative treatment, the only thing to do is to try to discover the condition early in order to change the activity of the affected worker, if there is still time, or retire him before he becomes disabled."

Protective equipment such as masks, respirators, and hoods should be used as a preventive measure. If collective

protection measures are insufficient, they should be carefully selected for specific sectors or functions. Workers must be properly trained in their use. Masks must be of good quality and appropriate for the exposures, with chemical or dust filters specific to each substance handled. Filters should be changed according to the manufacturer's recommendations.

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