

Silicosis and Associated Health Risks in the Mining Population of Jerada: A Review of the Literature

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Abstract:

Silicosis is a pneumoconiosis caused by prolonged inhalation of dust containing crystalline silica. It particularly affects mine and quarry workers. In the province of Jerada, a former coal mining region, this disease constitutes a major public health problem. This literature review aims to analyze the health impacts of silicosis among miners in Jerada, describe its prevalence, and identify prevention and management strategies.

A literature review was conducted using scientific databases (PubMed, Google Scholar, Scopus, JSTOR), institutional reports, and academic works published over the past twenty years. The included studies concerned populations exposed to silica with a confirmed diagnosis of silicosis. Publications in French, English, or Arabic were selected after evaluation of their methodological quality and clinical relevance.

The results show that silicosis primarily affects men aged 50 to 65 years with long-term occupational exposure to silica. Prevalence increases with the duration and intensity of exposure. The main complications observed are tuberculosis, the risk of which is multiplied in individuals with silicosis, and lung cancer. Smoking is a significant aggravating factor. Numerous studies also report the presence of pulmonary pseudotumoral masses and multiple respiratory comorbidities. Prevention measures and protective equipment remain insufficient in several mining contexts.

The data confirm that silicosis represents a major threat to the health of miners in Jerada. The duration of exposure to silica, the lack of adequate protection, and smoking contribute significantly to the severity of the disease. Prevention should be based on strengthening occupational safety measures, improving medical monitoring, and developing healthcare infrastructure. A multi-sectoral approach involving health authorities, employers and workers is essential to reduce the incidence of silicosis and improve the quality of life of those affected.

Keywords: Silicosis, Crystalline silica, Miners, Occupational exposure, Jerada, Pulmonary tuberculosis, Lung cancer, Occupational health, Prevention, Morocco.

I. Introduction

Silicosis is a chronic lung disease caused by prolonged inhalation of dust containing crystalline silica (Lacasse et al., n.d.). This disease belongs to the category of pneumoconioses, lung diseases caused by dust inhalation. It primarily affects workers in sectors such as mining and industries related to the extraction of silica-containing minerals.

Silicosis develops after repeated exposure to airborne crystalline silica particles. These particles are inhaled and settle in the lungs, where they trigger an inflammatory response. Over time, this inflammation leads to the formation of scar tissue, which reduces the lungs' ability to carry oxygen into the blood.

Indeed, silicosis can progress to chronic respiratory failure and even pneumonia. Affected individuals may also be more vulnerable to other lung diseases, such as tuberculosis. Due to advanced fibrosis, breathing without assistance becomes increasingly difficult. Without effective treatment and proper management, the disease can be fatal.

According to the World Health Organization (WHO), silicosis affects thousands of workers each year in high-risk sectors. However, with improvements in working conditions and prevention policies, new cases appear to be decreasing in some countries, although cases still exist in regions where occupational health regulations are inadequate.

Indeed, silicosis remains widespread in developing countries where working conditions in hazardous industries are less regulated. For example, a study conducted in India showed that over 4 million people working in stone quarries were exposed to dangerous levels of crystalline silica. In countries like China, and parts of Africa, silicosis remains largely underdiagnosed due to weak medical infrastructure and low awareness of prevention. Consequently, deaths from silicosis are more difficult to estimate because of the challenges associated with diagnosing and monitoring the disease.

In contrast, in the United States, the prevalence of silicosis among workers exposed in sand quarries and mines is estimated at approximately 1.5 to 3% of workers with more than 20 years of exposure. The Occupational Safety and Health Administration (OSHA) estimates that there are approximately 100 to 200 deaths each year due to silicosis.

In Morocco, silicosis is particularly widespread among workers in coal mines and some metal mines, especially in the eastern and southeastern regions of the country.

Although precise statistics on the number of cases are lacking, the age-adjusted annual mortality rate decreased from 31.4 per 100,000 people in 1990 to 0.7 in 2013. In Jerada, a city emblematic of coal mining from 1936 to 2000, approximately 9,000 workers were employed, of whom 2,018 were diagnosed with silicosis, representing almost 23% of those diagnosed. The objective of this literature review is to examine and synthesize existing knowledge on silicosis in the province of Jerada, focusing on its impact on health, prevalence statistics, and prevention and management strategies.

II. Materials and methods

The sources of information for this literature review will include several types of academic and institutional documents. Firstly, academic databases such as PubMed, Google Scholar, Scopus, and JSTOR will be consulted to identify relevant studies on silicosis.

Particularly those related to the Jerada region. In parallel, institutional reports from the Moroccan Ministry of Health, the World Health Organization (WHO), and other reports from governments and NGOs will be analyzed to gather recent data on silicosis and its health impact in the region. Specialized journals, especially those dealing with respiratory diseases and silica exposure, will also be a key source of information.

Finally, dissertations and theses on silicosis or occupational diseases in Morocco, particularly those addressing the province of Jerada, will be integrated into the journal in order to provide academic perspectives and field data on this public health issue.

The studies included in this review must meet several selection criteria to ensure their relevance and quality. First, only recent publications, dating from the last 20 years, will be considered to ensure the information is current. The types of documents accepted include scientific articles and public health reports. The scientific validity of the study must be rigorous: it must be methodologically sound, use representative samples, and include reliable statistical analysis.

Regarding the quality assessment of the selected studies, several criteria will be considered, including the inclusion of recent or current data, and the clinical impact and relevance of the studies: the information provided must be useful for the management of silicosis and for the implementation of public health strategies adapted to the Jerada region.

Regarding language, only studies written in French, Arabic, or English will be considered.

Inclusion criteria included studies focusing on populations exposed to silica, while studies without a confirmed diagnosis by chest imaging or pulmonary function testing were excluded.

III. Results

It is estimated that 49.5 million artisanal miners worldwide are exposed to high concentrations of silica in their work, resulting in significant morbidity and mortality due to silicosis and tuberculosis among exposed workers. (Howlett et al., 2025).

The study was based on an epidemiological analysis of silicosis cases recorded in several international and national databases. A review of the scientific literature was conducted to gather information on the impact of silica exposure on miners' health.

In all the articles analyzed, the study population is predominantly male. Indeed, almost all participants are male. This overrepresentation of men in the studies must be taken into account when interpreting the results, as it may limit the generalizability of the conclusions to female populations.

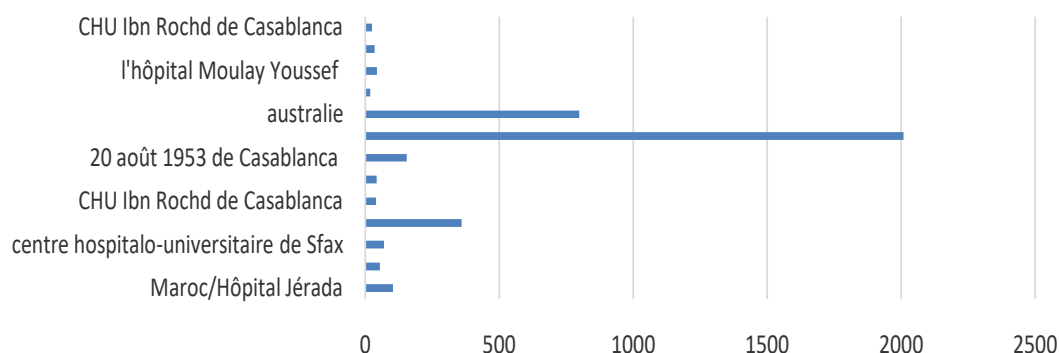


Figure 1: highlights a variation in the number of participants in the different studies analyzed, which could be explained by the sampling methods specific to each author.

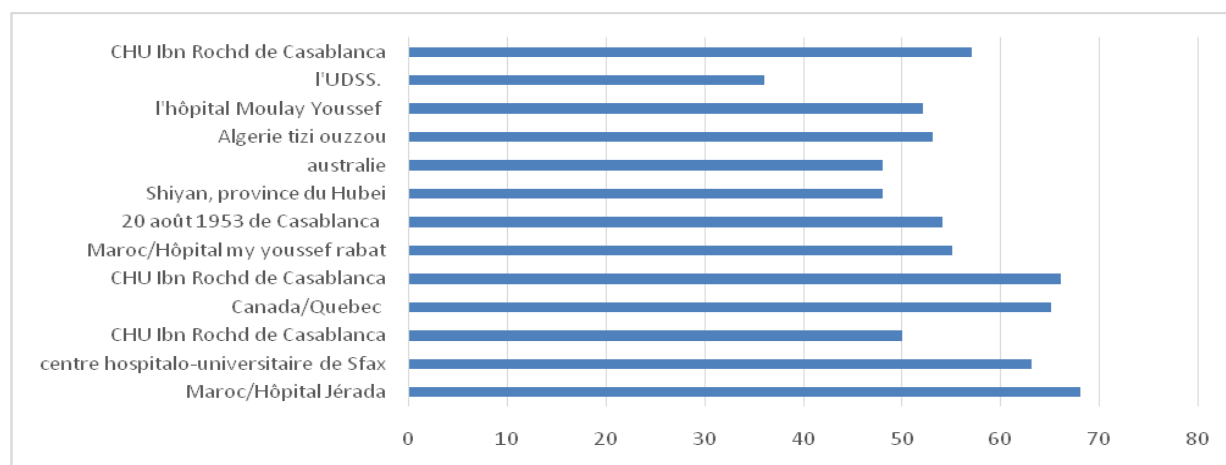


Figure 2: Distribution of the studied population according to age; The entire population included in the study belongs to the 50-65 age group. This reflects a population with significant seniority in the professional field, and thus able to bring rich and relevant experience to the issue being studied.

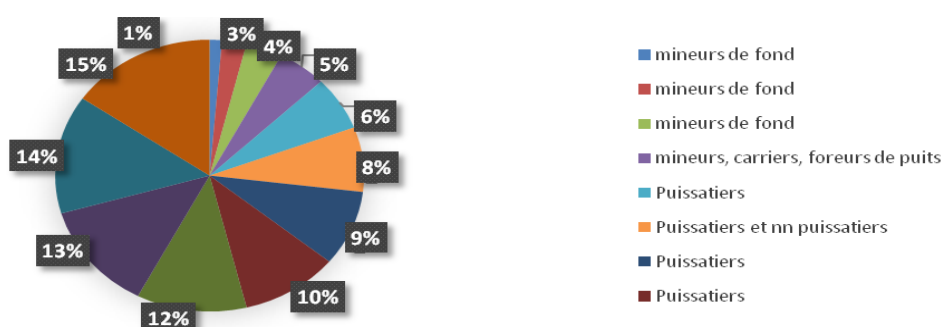


Figure 3: Distribution of the population by occupation

The distribution of the population by profession highlights the diversity of professional profiles included in the study. This heterogeneity enriches the analysis by combining perspectives and experiences from different work contexts, contributing to a better understanding of the issue at hand.

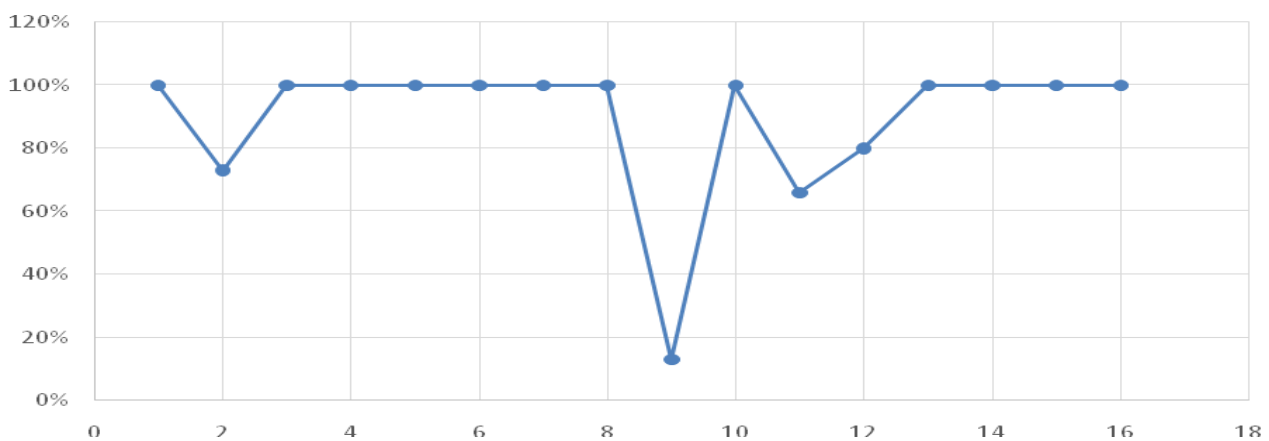


Figure 4: Distribution according to the percentage of silicosis in the population of each article

The distribution of silicosis rates in the population for each study shows significant variations between the studies. These differences can be explained by variations in occupational settings, exposure durations, or screening methods used. This heterogeneity underscores the importance of considering the specific characteristics of each study to interpret the results appropriately.

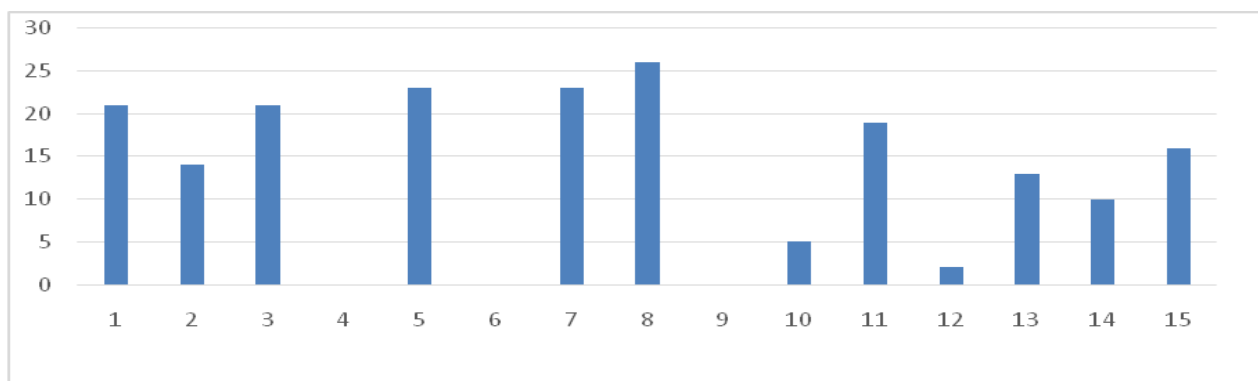


Figure 5: Duration of exposure to silica in years; The articles studied show a significant variation in the duration of subjects' exposure to silica, ranging from a few years to decades. This disparity strongly influences the onset and severity of silicosis cases.

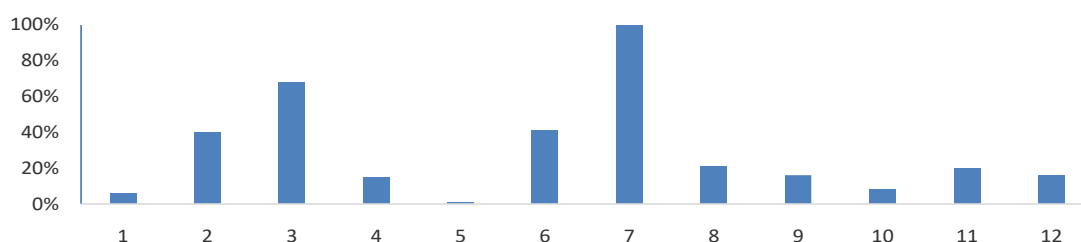


Figure 6: Tuberculosis rates in silicotic subjects; The rate of tuberculosis in silicotic individuals varies significantly in the general population. This observation is well documented in the scientific literature, ranging from 1% to 100% of cases.

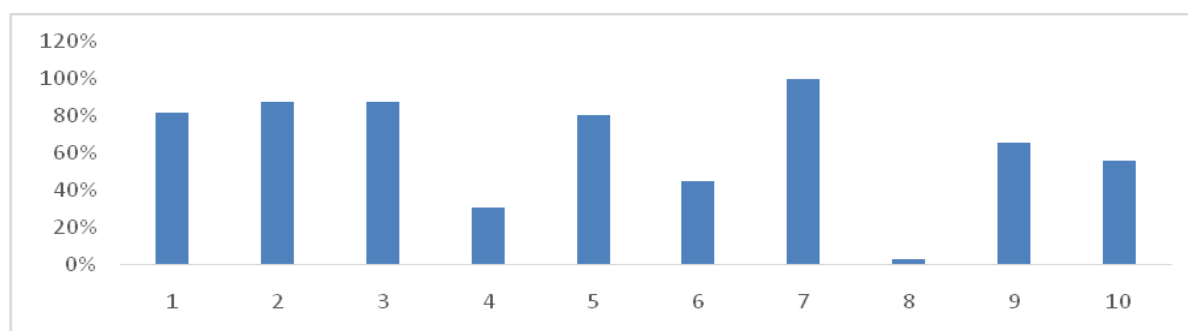


Figure 7: Cancer rates in people with silicosis; The graph shows a higher prevalence of cancer in patients with silicosis compared to the general population. People with silicosis have an increased risk of developing lung cancer.

Several studies have highlighted an association between silicosis and an increased risk of lung cancer. This relationship appears to be linked to the pro-inflammatory and fibrosing effect of crystalline silica, which can promote cellular alterations leading to cancerous transformation.

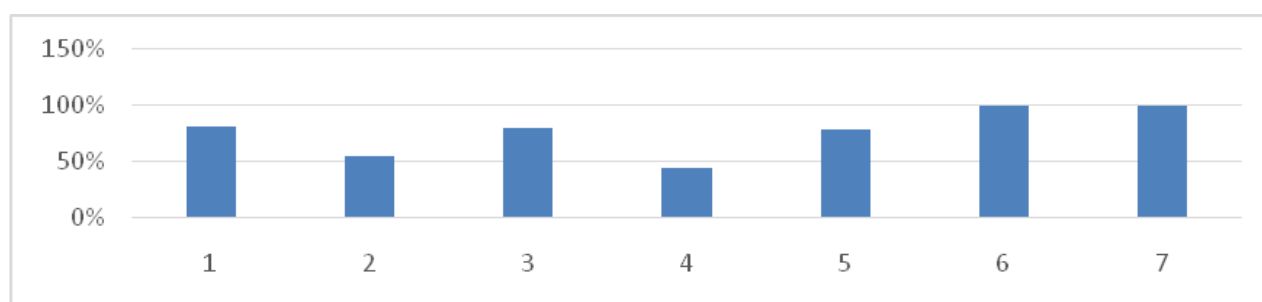


Figure 8: Percentage of pseudo-tumoral mass presence in silicotic patients; The graph highlights a significant proportion of silicosis patients presenting with pseudotumoral masses, confirming their high frequency in advanced stages of the disease. This trend underscores the importance of regular radiological monitoring to distinguish these benign lesions from malignant pathologies, particularly in the context of differential diagnosis.

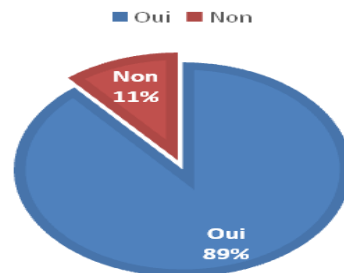


Figure 9: The rate of other comorbidities in silicosis patients; The figure shows that patients with silicosis have a high rate of comorbidities, reflecting the clinical complexity of this condition. Associated comorbidities frequently include chronic respiratory diseases (such as chronic bronchitis or emphysema), infections like tuberculosis, and cardiovascular disorders.

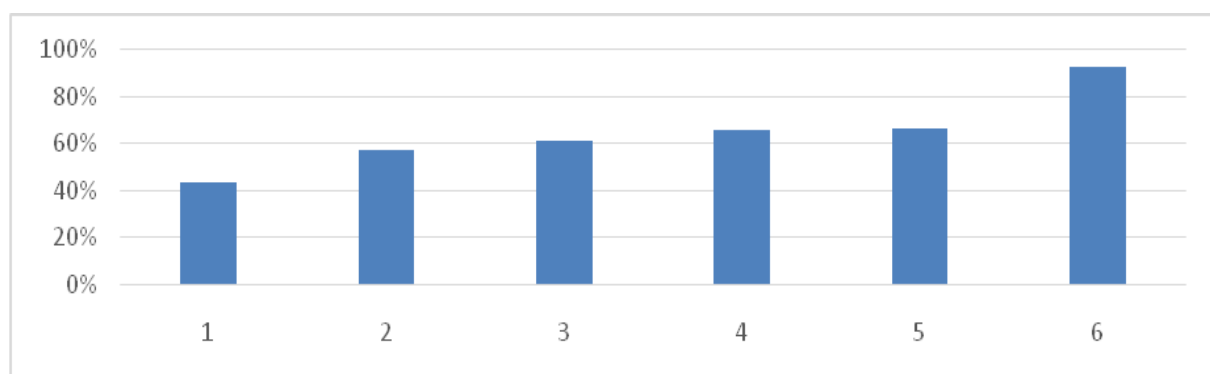


Figure 10: The rate of silicosis patients who smoke; The figure reveals a significant proportion of silicosis patients who are active tobacco users. This finding is particularly concerning, as smoking is an aggravating factor in lung deterioration, which is already compromised by silica exposure. The combination of silicosis and smoking increases the risk of severe respiratory complications, including lung cancer and chronic obstructive pulmonary disease (COPD).

Discussion

The results indicate a high prevalence of silicosis among coal mine workers. In Quebec, between 2006 and 2017, 360 new cases of occupational silicosis were recorded in men aged 35 to 96 years, with an average age of 64 years.

Professions such as well diggers, underground miners, quarrymen, well drillers, stonemasons, and stone crushers share a major risk factor: chronic exposure to silica dust. According to a study conducted in Jerada, silicosis exclusively affects a male population, with an average age of 54. Active smoking is found in 47% of patients, with an average consumption estimated at 21 pack-years. The most affected professions are well diggers (54.2%), masons (25.16%), underground miners (14.1%), and, to a lesser extent, workers in various industries (8%). Analysis of working conditions in these trades reveals a combination of risk factors, namely, high dust concentrations in confined spaces and poor ventilation. Data reported by Rees and Murray (2007) reveal an alarming prevalence of silicosis, exceeding 30% among underground miners exposed for more than 10 years without protective equipment. This statistic underscores the direct link between the duration of unprotected exposure and the development of the disease.

A retrospective study conducted by the University Hospital Center of Fez analyzed 50 cases of silicosis in Jerada, evaluating the patients' clinical, radiological, and functional profiles over a 20-year period. The results showed that ceasing silica exposure does not necessarily lead to a reduction in the severity of the disease (MAP, 2013).

For their part, Leung et al. (2012) emphasize the cumulative inhaled dose, which constitutes the best predictive indicator of silicosis risk. This reinforces the idea that it is not only the duration, but also the intensity of daily exposure (lack of ventilation, dry work, artisanal techniques) that determines the onset and severity of silicosis. The duration of exposure to crystalline silica is a determining factor in the development of silicosis. This lung disease is directly correlated with the cumulative dose of inhaled silica, itself a function of the silica concentration in the air and the duration of occupational exposure. Several longitudinal studies confirm that the risk of silicosis increases significantly with seniority in exposed occupations, particularly those of underground miner, stonecutter, driller, quarryman, or stone crusher (Leung et al., 2012; Steenland & Ward, 2014).

Available data indicate that chronic silicosis typically develops after 10 to 20 years of moderate exposure, while accelerated or acute forms can occur after only 5 to 10 years, or even a few months in cases of massive exposure (NIOSH, 2002; Hnizdo & Vallyathan, 2003). This highlights a dose-dependent gradient that is particularly concerning in environments where preventive measures are inadequate or nonexistent. Furthermore, the duration of exposure is not only a quantitative indicator but also a qualitative one: intermittent but intense exposures can have effects as detrimental as continuous low-dose exposure.

Cohorts monitored by the International Agency for Research on Cancer (IARC) and the National Institute for Occupational Safety and Health (NIOSH) show that the recommended occupational exposure limit of 0.05 mg/m³ (8 h/day, 40 h/week) is routinely exceeded in the stone, drilling, and construction sectors (NIOSH, 2011). Workers with exposure durations exceeding 15–20 years have a

silicosis prevalence of up to 30%, particularly in the absence of adequate ventilation or respiratory protection (Chen et al., 2001; Calvert et al., 2003).

The socio-professional analysis of these occupations highlights a population often from disadvantaged socio-economic backgrounds, sometimes working in small-scale, artisanal businesses.

Silicosis is now widely recognized as a major risk factor for the development of pulmonary tuberculosis. According to Corbett et al. (2000), in a study of South African miners, the prevalence of active tuberculosis among those with silicosis is 18%, compared to approximately 2% in the general population of miners without silicosis. The relative risk is three to four times higher.

The data reported by Hnizdo and Murray (1998) unequivocally demonstrate a relationship between the severity of silicosis and the risk of active tuberculosis. Prevalence increases from 6.3% in mild cases to 25.2% in severe cases, highlighting the failure of the local immune system to control *Mycobacterium tuberculosis* in deeply damaged and fibrosed lung tissue. This relationship is reinforced by the results of Ehrlich et al. (2006), who, in their systematic review, estimate that individuals with silicosis have a 2.8 to 39 times greater risk of tuberculosis. The study by Chen et al. (2001) in China confirms these observations, with a prevalence of tuberculosis reaching up to 30% among workers with silicosis, particularly those with prolonged exposure (>15 years).

According to data from the analyzed studies, a high prevalence of cancer is observed in individuals with silicosis, with rates ranging from 3% to 100%. This finding aligns with the results of Steenland and Ward (2014), who, in a meta-analysis of over 60 studies, reported a relative risk (RR) of lung cancer between 1.3 and 3.0 in workers exposed to silica.

Furthermore, Liu et al. (2013), in a large cohort study conducted in China with 35,000 exposed workers, found a lung cancer rate of 4.3% in subjects with silicosis, compared to 1.7% in the unexposed population.

For their part, Calvert et al. (2003), through an analysis of mortality in the United States, highlighted excess mortality from lung cancer in individuals with silicosis, particularly among former miners and stonemasons.

Among the 16 articles analyzed, five highlighted a high proportion of smokers among people with silicosis. This interaction between silica exposure and tobacco use appears particularly concerning. Indeed, according to Checkoway et al. (1999), a worker who smokes and is exposed to silica has a 4 to 6 times greater risk of developing lung cancer compared to a non-smoker who is not exposed.

Scientific data confirm that smoking significantly worsens lung damage in workers with silicosis.

The International Agency for Research on Cancer (IARC) has classified both crystalline silica and tobacco in Group 1, meaning they are carcinogenic to humans. However, the combined effects of these

two factors are far from simply additive: they are synergistic, meaning that their interaction leads to an increased risk well beyond the sum of their individual effects.

Checkoway et al. (1999) reported that the relative risk (RR) of lung cancer is approximately 2 in non-smoking individuals with silica, but that it rises to 4.5 in smoking individuals with silica, confirming the existence of a multiplicative effect.

A Chinese study conducted by Liu et al. (2013) on a cohort of 34,000 workers corroborates these data: the lung cancer rate was 2.1% in non-smoking silicotic patients, compared to 6.9% in smoking silicotic patients, representing a risk more than three times higher.

The pseudotumoral masses observed in patients with silicosis are generally composed of conglomerates of silicotic nodules, without signs of pleural invasion or suspicious lymphadenopathy. Despite their often suggestive appearance of a tumor, these lesions are overwhelmingly benign.

Among 16 articles analyzed, 7 reported a high rate of pseudotumoral masses, ranging from 56% to 100% of cases; Marchand et al. (2010) evaluated this issue in 48 silicotic patients with a suspicious lung mass: only 12% of cases turned out to be cancers, the others being related to inflammatory conglomerates, tuberculosis or benign silicotic lesions.

However, Bégin et al. (1991) described these lesions as "carcinomimetic pseudomasses" due to their strong radiological resemblance to malignant tumors, particularly in advanced forms of complicated silicosis or progressive massive fibrosis. These masses are often larger than 1 cm in diameter.

A retrospective study of 157 cases of pseudotumoral silicosis was conducted in the respiratory diseases department of the 20 August 1953 Hospital in Casablanca between July 2000 and July 2022. The patients had an average exposure to silica dust of 21 years. Clinically, dyspnea was present in 95% of cases, followed by dry cough (40%), chest pain (50%), and hemoptysis (30%). Chest X-rays revealed bilateral confluent nodular opacities with a pseudo-tumoral appearance in 88% of cases, associated with diffuse micronodular opacities in 16%. Chest CT scans showed partially calcified tissue-density masses in 68% of cases, often accompanied by eggshell-like calcified lymphadenopathy in 42% of cases.

The prevention strategies analyzed in the studies reveal insufficient efforts to control silica exposure in mines. Although regulations have been put in place by the Ministry of Health and regulatory bodies to limit dust exposure, these measures are often poorly implemented due to a lack of resources and inadequate oversight. The research documented that the use of personal protective equipment, such as respirators, is limited and ineffective due to poor quality and non-compliance with international standards (Ehrlich et al., 2021). From a socio-economic perspective, silicosis has a considerable impact on workers' quality of life and represents a significant economic burden on public health systems. The costs associated with medical care, lost wages, and compensation for occupational diseases place a heavy burden on company and government budgets. Implementing stricter prevention policies could help reduce these costs while improving worker health.

Regarding medical care, several studies show that healthcare services in Jerada are insufficient to adequately treat silicosis. Patients suffering from silicosis require specialized care, but this care is often unavailable in the region, forcing many workers to travel to other cities for more advanced treatment. (Yabiladi.com, n.d.) This highlights the importance of enhanced training for local doctors and improved healthcare infrastructure to better care for sick workers.

Studies suggest that reducing silicosis in Jerada requires a combination of strengthened prevention strategies and improved patient care. Experts recommend strict enforcement of workplace safety regulations, improved personal protective equipment, and regular medical monitoring of workers exposed to silica. Furthermore, awareness programs should be launched to educate both workers and mine managers about the dangers of silica and the importance of prevention (MAP, 2013).

Conclusion

Chronic exposure to crystalline silica doubles to triple the risk of lung cancer compared to the unexposed population. This risk is exacerbated by the duration of exposure and smoking. These data fully justify the inclusion of exposed workers in epidemiological surveillance and early cancer screening programs, particularly through regular radiological examinations or targeted molecular detection tests.

Pseudotumoral masses, especially in pulmonary silicosis, frequently pose a diagnostic challenge in differentiating them from lung cancer. Numerous studies converge on the need to combine high-resolution imaging, a thorough occupational history, and histological examinations to establish a definitive diagnosis. In regions with a high prevalence of silicosis, their recognition is essential to avoid costly diagnostic errors with clinical, psychological, and therapeutic implications.

A lasting eradication of silicosis requires a concerted approach involving health authorities, employers, and workers. Improved prevention and treatment strategies, supported by scientific advances and innovation, will be essential to better manage this disease and limit its impact on public health and the global economy.

To better combat silicosis in Morocco, especially in Jerada, it is essential to strengthen epidemiological surveillance, improve working conditions for at-risk populations, and implement stricter policies for prevention and early detection. A multisectoral commitment involving health authorities, employers, and workers is necessary to reduce the incidence of this disease and improve the care of those affected.



Reference

- Ehrlich, R., Akugizibwe, P., Siegfried, N., & Rees, D. (2021). The association between silica exposure, silicosis and tuberculosis : A systematic review and meta-analysis. *BMC Public Health*, 21(1), 953. <https://doi.org/10.1186/s12889-021-10711-1>
- Howlett, P., Said, B., Mwanga, E., Mbuya, A., Nota, M., Kon, O. M., Gottesfeld, P., Feary, J., Mpagama, S., & Ehrlich, R. (2025). Confronting the growing epidemic of silicosis and tuberculosis among small-scale miners. *The Lancet Public Health*, 0(0). [https://doi.org/10.1016/S2468-2667\(25\)00014-3](https://doi.org/10.1016/S2468-2667(25)00014-3)
- Lacasse, Y., Martin, S., & Desmeules, M. (s. d.). Silicose, silice et cancer du poumon : Méta-analyse de la littérature médicale.
- MAP. (2013, juin 23). Jerada : L'unité de prise en charge des silicotiques, une illustration de la sollicitude royale envers les personnes atteintes de cette pathologie. *Le Matin.ma*.
https://lematin.ma/journal/2013/Declaration_JeradaA-l-unite-de-prise-en-charge-des-silicotiques-une-illustration-de-la-sollicitude-royale-envers-les-personnes-atteintes-de-cette-pathologie/184118.html
- Yabiladi.com. (s. d.). Une étude suggère une piste thérapeutique pour la silicose, la maladie mortelle de Jerada. Consulté 24 mars 2025, à l'adresse
<https://www.yabiladi.com/articles/details/72281/etude-suggere-piste-therapeutique-our.html>