



## A Mini Review on Tuberculosis Risk in Coal Mining: A Matter of Exposure or Environment?

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Received: 2025-07-22

Revised: 2025-08-12

Accepted: 2025-08-16

### ABSTRACT

Particularly in high-risk work environments like coal mining, tuberculosis (TB) continues to be a major worldwide health concern. The relationship between coal dust exposure and tuberculosis is still unclear, despite the fact that silicosis, a frequent occupational lung disease among miners, is known to be associated with an elevated risk of tuberculosis. The complex interactions between environmental, occupational, and social variables that affect coal miners' susceptibility to tuberculosis are examined in this narrative review. Even in the absence of clinical silicosis, the fluctuating silica concentration of coal dust significantly raises the risk of silico-tuberculosis. Furthermore, TB transmission and progression in mining communities are made worse by inadequate ventilation, crowded living conditions, HIV co-infection, labour movement, and limited access to healthcare. According to epidemiological statistics, miners are at a markedly increased risk of developing both pulmonary and extrapulmonary tuberculosis, especially in low-income areas with inadequate occupational safety regulations. The clinical and radiographic characteristics of silicosis and tuberculosis coincide, making diagnosis even more challenging. The review highlights urgent research needs in pathophysiology, prevention strategies, and integrated control programs. Thorough dust control, health education, TB prophylaxis, and strong occupational health regulations specific to mining settings are all necessary for effective TB mitigation in mining communities.

**Keywords:** Tuberculosis (TB), Coal-Miner, Environmental Exposure

### INTRODUCTION

Nearly one-ninth of all fatalities worldwide are attributable to tuberculosis (TB), one of the most common infectious illnesses brought on by *Mycobacterium tuberculosis*. Long-term strategies like the Sustainable Development Goals and the End TB Strategy are being carried out with the comparable goal of decreasing the death rate to 90% and incident rate to 80% in 2030 compared to that of 2015 in order to reduce incidence, mortality, and end the global TB pandemic (1, 2). Antibiotic resistance is proving to be a barrier to achieving the desired results, despite the fact that global epidemiological data shows a consistent drop in TB incidence and TB-associated fatalities in recent years (3-5). Despite being treatable with antimicrobial medications, tuberculosis (TB) continues to be the most common infectious agent-related cause of mortality in the twenty-first century. About 1.4 million people died from tuberculosis in 2019, while an estimated 10 million individuals contracted the disease (6, 7). Dust generation in and around mining regions has surged as a result of the mines' quick expansion and rising productivity. According to estimates, every tonne of coal typically produces 10–100 g of dust smaller than 5  $\mu$ , with 1% of the dust being lost to the atmosphere (8, 9). As of right present, there is no particular therapy for the well-known occupational fibrotic lung condition pneumoconiosis. Pneumoconiosis rates are among the highest in the world in China. More than 85% of all occupational illnesses that are recorded in the nation are caused by it. About 60% of all new cases of pneumoconiosis are thought to be of the coal workers' pneumoconiosis (CWP), which is thought to be the most prevalent kind (10, 11). Prior research has clearly demonstrated the link between pulmonary tuberculosis (PTB) and pneumoconiosis. The increased morbidity and mortality from PTB among workers exposed to silica dust has been confirmed by epidemiological research and case reports (12, 13). Since the late 19th century, it has been recognized that silica exposure affects lung health, particularly its involvement in TB susceptibility. Experimental tests later demonstrated that crystalline silica had a depressive impact on alveolar macrophages' capacity to eliminate *Mycobacterium TB* (14, 15). Research indicates that silica exposure alone, even in the absence of silicosis, raises the lifelong risk of TB (16-18). On the other hand, it is



unclear how exposure to coal dust and tuberculosis are related. One known risk factor for occupational lung conditions including coal workers' pneumoconiosis (CWP) and chronic obstructive pulmonary disease (COPD) is dust exposure in coal mines (17, 19). In contrast to silicosis, there is very little concrete proof of a link between TB and coal dust exposure, whether CWP is present. Exposure to coal dust as a direct risk factor for M. tuberculosis infection is perhaps questionable. There are insufficient pathophysiological explanations for this connection. "CWP by itself does not carry an increased risk for mycobacterial infection, either by M.tb or nontuberculous Mycobacteria (NTM)," according to Ross, a member of the South African Safety in Mines Research Advisory Committee (20, 21).

### Socioeconomic and Environmental Factors

In 1963, the first thorough investigation of South African coal miners revealed that among 1010 miners who had autopsies, there was a notable frequency of both TB (25.4%) and CWP (26.8%) (16, 22). Since then, a number of studies have proposed a causal linkage between TB and coal mining, citing dose-dependent interactions with coal dust exposure and positive correlations with CWP (20, 23, 24). Crucially, silica can vary in concentration based on coal rank and may or may not be a component of coal dust. Substantial concern exists regarding the reliability of silica measurements in both the mining and non-mining sectors, as sampling errors, equipment calibration, environmental factors and competing particle interference can all influence readings (25, 26). Despite inaccuracies in absolute measurements of silica content, this concept of variability is highly relevant when interpreting causality, as higher silica content in higher-rank coal may exacerbate the risk of mixed dust pneumoconiosis, silicosis and TB (27, 28). Geographical variability in coal rank and silica content is wide, with South African coal mines falling into lower ranks with less silica content (14, 29). The increased incidence of tuberculosis in coal mining environments is also greatly influenced by environmental and occupational variables. Inhaling silica dust produced during mining activities is a serious risk factor since it can lead to silicosis, a chronic lung disease that seriously impairs lung function and raises the risk of tuberculosis (30, 31). Mycobacterium tuberculosis and other airborne diseases can survive and spread among miners in deep mines due to inadequate ventilation. Furthermore, long-term exposure to coal dust and other pollutants damages the respiratory system, impairing the body's defences and increasing a person's vulnerability to tuberculosis. Co-infection with HIV, a virus that seriously compromises immunity and speeds up the transition from latent to active TB, increases the risk for miners (32, 33). Due in part to the temporary nature of mining job, which might increase susceptibility to STDs and interfere with regular access to treatment, miners are more likely to have HIV (34, 35). Another element that fuels the persistence and development of tuberculosis in coal mining areas is labour movement. It is challenging to ensure continuity of care for patients receiving TB therapy since many miners migrate from far-off rural regions to work in the mines. Additionally, the temporary nature of the mining workforce makes it easier for TB to spread among many communities and geographical areas (36, 37). Miners are sometimes deterred from obtaining prompt medical assistance by structural and cultural impediments, such as the stigma attached to tuberculosis and the fear of losing their jobs. Effective treatment can also be further limited by communication gaps that arise between mining communities and healthcare professionals due to language barriers and a lack of culturally competent health services (38, 39). Institutional and policy shortcomings also play a role in sustaining TB risk (40, 41). Workers in the mining sector are exposed to avoidable health risks in many nations due to lax or poorly implemented occupational health standards. The unique medical requirements of miners are frequently not sufficiently met by government investment in healthcare facilities in mining areas (40, 42). Overall, addressing TB in coal mining populations requires a multifaceted (43, 44) approach that includes enforcing workplace safety standards, improving housing and healthcare access, offering health education, and ensuring that TB prevention and treatment programs are integrated into mining communities. Only by tackling both the socioeconomic and environmental drivers of TB can we hope to reduce its impact in these high-risk settings (45, 46).

### Epidemiology

The true burden of individuals exposed to silica dust or afflicted by silicosis in nations with little resources is unknown because of inadequate monitoring and restricted access to medical care, making it difficult to determine the incidence of silico-tuberculosis globally (47, 48). In any case, the rates of silicosis and of silico-tuberculosis are higher in low-income countries because of poor adherence to safety rules, limited preventive equipment and lower education (47, 49). Few published studies have affected the silico-tuberculosis prevalence, and the literature largely consists of case reports. The relative risk to develop pulmonary tuberculosis for patients with silicosis has been estimated to be 2.8, and extra-pulmonary tuberculosis can be up to 3.7 times higher than in individuals without silicosis (49). The increased risk of both pulmonary and extrapulmonary tuberculosis is linked also to exposition to silica (50), can continue for years even if the exposure ends (51), increases with the severity of silicosis, and is higher in patients with acute and accelerate forms of the disease (52). Crucially, at least 50% of TB cases were linked to continuous transmission within the mining community, and in 85% of patients in clusters, transmission was attributed to current or previous mine work, according to DNA fingerprinting (53). Male gender (99% of cases), old age, and pulmonary/pleural TB were significantly associated to cases of silico-tuberculosis in an analysis of all patients notified with tuberculosis between 1999 and 2012 in Portugal (54). Smear-negative and positive culture sputum were more frequent in silico-tuberculosis; interestingly, a higher risk for extra-pulmonary TB was not confirmed in this study (54). In a prospective study evaluating 1153 South African gold miners, the annual incidence of tuberculosis



was 2.7% in those with silicosis, compared with 0.98% in those without (50), whereas in a study done in Hong Kong and assessing the efficacy of chemoprophylaxis in patients with silicosis, the annual incidence of tuberculosis was 7% in the group receiving placebo (55).

A study involving 2255 South African gold miners who were monitored for 24–27 years revealed a mean of 7.6 years between the end of silica dust exposure and the diagnosis of pulmonary tuberculosis. The study also found that the severity of silicosis, if present, and the intensity of exposure are related to the risk of developing pulmonary tuberculosis (51). The association between crystalline silica exposure and silicosis and pulmonary tuberculosis was clearly confirmed in two other studies (56). In particular, in a US study the cumulative degree of exposure to silica increased the risk to develop silico-tuberculosis with a mean odds ratio of 1.47, that increased to 2.48 in the group with more intense exposure (56). In another study on 381 gold miners with pulmonary tuberculosis, the risk of TB increased for the miners who had worked for over 10 years, with an OR of 1.9; if exposure had been longer than 15 years, the risk was four times higher than in controls (57). Silicosis and HIV infection are powerful risk factors for TB and add to each other (34). HIV infection raises TB incidence by increasing the risk of reactivation of latent *Mycobacterium tuberculosis* infection and favouring more rapid progression from infection to disease. In a prevalence study involving 624 former gold miners from Lesotho, eighteen months after their employment at a South African mine had been terminated, almost 25% had silicosis; 26% of those for whom data was available, had a past history of TB; 1.3% were already on anti-TB drugs; 2.9% had active, undiagnosed TB; and 2.1% were put on anti-TB treatment on clinical grounds (58). 22.3% of subjects had urine anti-HIV antibodies (58).

### Clinical features

Pleural tuberculosis is by far the most common form of extrapulmonary TB (59), followed by pericardial and lymph nodal forms (60); intracranial, spinal, soft tissue, and disseminated TB are rarer (52). Although the diagnosis of active tuberculosis on top of silicosis can be challenging, especially in the early stages when clinical manifestations may not be indicative and radiological alterations may be indistinguishable from those caused by the pre-existing silicosis, the presence of typical features of pulmonary TB, such as persistent cough, fever, weight loss, or hemoptysis, can allow suspicion of the diagnosis. Radiologically, the discovery of pleural effusion or excavations, as well as the quick emergence of new opacities, should cause alarm. In general, it is difficult to identify active illness in silicosis patients based on clinical criteria. Because the patient may occasionally be asymptomatic and the disease is unintentionally detected by chest radiography, the clinical spectrum of pleural TB varies (47). The symptoms of tuberculous pericarditis are generally nonspecific (fever, weight loss, and night sweats) (32), but a few patients present in late stages with the signs and symptoms of constrictive pericarditis (20).

### Main research needs

Additional studies are clearly needed on the pathophysiology of silico-tuberculosis. In particular, no research has been done on dendritic cells, neutrophils, NK cells, B cells, and only scant and contradictory data are available on T cells (43). National silicosis control initiatives should be combined with tuberculosis control initiatives, and the results of this combination should be examined. It's also important to look into the results of awareness efforts that educate mine workers about the dangers of silicosis and the need of wearing personal protective equipment. Lastly, further research is needed on TB prevention treatment plans as well as the management of TB in silicosis patients.

### Conclusion

In individuals with silicosis, tuberculosis remains a significant concern. To track how well control measures are working, it is necessary to enhance the monitoring and reporting of silicosis and tuberculosis among former miners. Strong enforcement of dust control regulations is required, as are extensive TB preventive initiatives for miners who are currently employed. It may be impossible to implement serious dust control measures in certain workplaces, such as gold mines in low- and middle-income nations where deep-level mining takes place in continuously shifting environments. Surprisingly, however, these measures are not implemented even in high-income nations, like Australia. It is also necessary to address the issue of certain nations' mining rules lacking crystalline silica exposure limitations. It is very difficult to find a solution to the TB problem because, in many cases, if workers are not allowed to remain in the mines due to their TB status, they will return to their generally impoverished communities, where it will be very difficult to complete a course of treatment and where TB transmission is likely to occur. If they are permitted to continue working, TB will spread more widely within the mines. among any event, chemoprophylaxis must be extended globally to lower the prevalence of extrapulmonary and pulmonary TB among miners.

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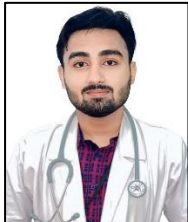
How to cite this article:

Dr. Morziul Haque<sup>4</sup> et al. *Ijppr.Human*, 2025; Vol. 31 (8): 17-22.

Conflict of Interest Statement: All authors have nothing else to disclose.

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