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Silicotuberculosis in South Africa: forgotten in history, neglected in science

A brief overview

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INTRODUCTION

Silicosis and pulmonary tuberculosis (TB) are distinct diseases but frequently co-occur in settings in which workers inhale silica dust. There have been different conceptions of combined disease, associated with differences in terminology, as explained below. However, silicotuberculosis is defined here as the combination of silicosis and tuberculosis, whether the tuberculous component is active disease requiring treatment, or post-TB lung disease ('old TB'). Relative to silicosis alone, silicotuberculosis is associated with increased lung function impairment, poorer outcomes in treatment, and increased mortality.[1-3]

In this overview, I argue that silicotuberculosis has received insufficient scientific and medical attention over the past half century or so. The context is the South African gold-mining industry, but the argument extends to the English-language literature, globally. My perspective is influenced by Rosental's analysis of the International Labour Office (ILO) Silicosis Conference held in Johannesburg in 1930.[4] In Rosental's view, the international medical definition of silicosis was shaped by the needs of the South African mining industry, particularly in developing a manageable system for medical exclusion and compensation. One consequence for science and practice was a narrowing of the field of vision and scope of research on the effects of silica dust.

Lethal miners' phthisis – dust or TB?

By 1900, there was a lethal epidemic of miners' phthisis in the new South African gold-mining industry.[5] There had already been a century of medical argument about the causes of lung disease in such dusty industries. After Koch's discovery of the tubercle bacillus in 1882, the view took hold that TB was a necessary factor in miners' phthisis.[6] It was believed that dust played a role, but that TB was responsible for the serious effects, including premature mortality.[6] This view presumably underlies the listing of both silicosis (in 1912) and TB (in 1917) as compensatable diseases in miners under South African law. However, only at the 1930 Silicosis Conference was a consensus expressed that silica dust on its own could cause serious disease.[4,6]

Silicosis and silica as contributing causes of TB

The literature up to the 1960s is striking in the almost unanimously expressed belief that silica dust and silicosis predisposed to TB. However, from at least the 1930s, Orenstein, medical advisor to Rand Mines Ltd., denied the aetiological association between silica, silicosis, and TB.[7] Almost 50 years later in 1978, Martiny, the medical advisor to the industry recruiting agency, the Witwatersrand Native Labour Association (WNLA), stated that *"TB is not a mining disease"* in an unpublished memorandum to the South African Parliament to have TB removed from statute as a compensatable disease in miners *("Comments on Revision of the Plural Affairs code – pneumoconiosis and tuberculosis; 1978")*. At about the same time, Cowie, a specialist physician at Anglo American's Ernest Oppenheimer Hospital in Welkom, expressed the opinion that given the replacement of accelerated silicosis by the slowly progressive chronic form of silicosis, and the availability of short-course TB treatment, the aetiological association between silicosis and TB had lost much of its practical importance.[8,9]

However, within the next decade Cowie published evidence of an almost trebling of the TB risk in miners with silicosis.[10] There is little in the public domain on how this finding was managed internally within the gold-mining industry but, from my observation at the time, it appears that the association was accepted and the question shifted to that of whether TB could be attributed to silica exposure in the absence of silicosis. This was a more difficult question to answer, as it required studies able to measure dust exposure and in which silicosis could be controlled for in the analysis. To further complicate the question, *"absence of silicosis"* should have been *"absence of radiological silicosis"*. This follows from a study by Hnzido and Sluis-Cremer, based in the Epidemiology Research Unit attached to the Medical Bureau for Occupational Diseases, which showed that two thirds of the silicosis cases identified at autopsy were not visible as such on the chest X-ray (CXR).[11] This finding seems to have had little influence on conceptions of the influence of silica and silicosis on TB and other diseases, both in South Africa and in the global literature more generally.[12]

The 2000s brought a surge in publications on human immunodeficiency virus (HIV) and TB in gold miners. The singular association between silicosis and TB was replicated in a number of studies.[13-15]

Silicosis was shown also greatly to aggravate the association between HIV and TB. In HIV-infected miners, the unadjusted relative risk of TB was reported in 2000 to be 4.5.[15] In miners with both HIV infection and silicosis, the relative risk for TB was more than three time higher, at 14.6.

In 2018, six large gold-mining companies settled a class action suit for silicosis and TB contracted by their employees.[16] Each disease is assessed separately under the Trust Deed of the Tshiamiso Trust, the civil trust formed in the wake of the settlement, and respiratory impairment and compensation grade are determined from the results of spirometric testing.[16,17] This formulation is in contrast to that in the Occupational Diseases in Mines and Works Act (ODMWA) under which TB combined with any other disease (commonly silicotuberculosis) is automatically classified as second degree (equivalent to *"> 40% impairment"*). This certification carries a substantially greater payout than does first degree.[18]

Occupational health management of miners with silicosis and tuberculosis

By the 1970s and 1980s, resistance had developed within the gold-mining industry to the longstanding statutory requirement that miners diagnosed with silicosis or TB (active or with evidence of old TB) be excluded from risk work. This resistance arose from a change in labour regimen towards retention of skilled and returning migrant workers,[19,20] and was influenced by medical research within the industry, which showed that short-course TB treatment was curative and not impaired by co-existing silicosis.[21] Changes in mining company practice,[9] followed by statute,[18] resulted in the dropping of automatic exclusion of individuals with silicosis or TB from risk work. This did not apply to combined disease, which continues to require exclusion from risk work. Follow-up studies were few. An exception was Cowie's demonstration that miners with silicosis had a 50% greater TB treatment relapse rate than those without silicosis.[22]

Linkage of silicosis to TB programmes

By the 2010s, international interest had turned to combatting TB in southern Africa[23] – by the World Health Organization, the World Bank, and the Global Fund to Fight AIDS, Tuberculosis and Malaria. One outcome of this international interest was the Global Fund-financed programme, Tuberculosis in the Mining Industry in Southern Africa (TIMS), from 2017 to 2018.[24] This programme provided the resources for an eight-country programme, excluding South Africa, to screen and treat TB in miners, ex-miners, and community members in countries neighbouring South Africa. Included was a protocol for submission of the claims of migrant workers from the South African mining industry for compensation under the ODMWA. Based on quarterly reports, more than 200 000 people were examined from July 2016 to September 2018 (of which the majority can be assumed to have been miners or ex-miners).[24] However, the opportunity to expand our knowledge of the epidemiology and clinical characteristics of the two diseases in this large ex-miner population was taken up by only one centre, based in Lesotho.[25,26]

Looking back

In returning to the literature on combined disease in the first two thirds of the 20th century, prolific publication on all aspects of combined disease is evident from South Africa, the United Kingdom, and the United States (from English-language sources). The multidisciplinary coverage included pathology, physiology, radiology, and clinical science.[27-32] By the 1970s, this literature appears to have been largely forgotten and seldom referred to. Tony Davies, at the National Centre for Occupational Health,[33] and Cowie[9] were exceptions, and it took professional historians to bring this work to wider attention. This included the work of Rosental mentioned above, McCulloch[20] and, more recently, McCulloch and Miller.[34]

An interesting mid-century example is the 1964 paper by Gerrit Schepers.[35] The 18-page article lacks references, but is an unusually comprehensive source of experimental and clinical observation and accompanying theory of interaction. Schepers had worked at the Miners' Phthisis Medical Bureau in Johannesburg from 1944 to 1954, before emigrating to the United States, where he spent the first three years at Saranac Laboratory, a centre of research into TB and mineral dust disease.[20] His paper provides a systemic classification of the pathogenesis and clinical presentation of different disease phenotypes due to silica exposure and TB infection, depending on the temporal sequence. These are briefly summarised in Table 1.

While the body of work referred to above predates the era of modern short-course treatment of TB and reflects higher silica dust exposures, the late 20th century/early 21st century epidemic of silicotuberculosis in South Africa calls for a reconsideration of everything learned about combined disease.

Somewhat later, in the 1980s, Solomon published two papers based on his long experience as an occupational radiologist, which reflected close observation of the radiological appearances of silicosis and TB in miners.[36,37] In these articles, he identified a nodular presentation of TB (other than that of miliary TB) that may complicate silicosis, including an 'indolent' form in which the sputum was frequently negative for TB.

Looking ahead

There is a need for an active research programme in the pathophysiology, pathology, radiology, and clinical science of silico-tuberculosis (as defined in the Introduction) as a specific phenotype resulting from exposure to silica and *Mycobacterium tuberculosis*. Table 2 suggests a number of lines of research for revival or initiation.

Table 1. Schepers' classification of phenotypes of combined silica exposure and TB infection[35]

Phenotype	Temporal pattern	Clinical outcome
Tuberculosilicosis	Silica exposure follows TB infection ('reactivation')	Reactivation of TB disease, with tendency to indolent chronic disease
Silicotuberculosis	TB infection contemporaneous with silica exposure ('simultaneous phase')	Rapidly developing tissue destruction and fibrotic disease, with fatalities
Silicosis with tuberculosis	Active TB superimposed on silicosis ('predisposition phase')	Rapidly disabling disease with high fatality rate, irrespective of whether TB occurs during or after silica exposure

Table 2. Needed lines of inquiry into silicotuberculosis

Topic	Line of inquiry
Pathogenesis	How silica particles and *Mycobacterium tuberculosis*, and the disease processes of silicosis and TB, modify each other. This should include consideration of the influence of the temporal sequence of exposure, infection, and disease, in addition to dose and duration
Epidemiology	Long-term cohort study of miners to determine the natural history of silicotuberculosis, including mortality. In southern Africa, these include living cohorts who worked on the South African mines and new cohorts, such as informal and small-scale miners in South Africa and other countries such as Zimbabwe[38]
Radiological differential diagnosis	Role of computed tomography in distinguishing between silicosis, TB, and silicotuberculosis
Impairment	Role of diffusing capacity for carbon monoxide (DLco) in silicotuberculosis, thus expanding the measurement of pathophysiology beyond spirometric lung volumes
Diagnosis of active TB	Influence of silicosis on the performance of CXR and of microbiological tests in detection of active TB
Treatment of TB	Effectiveness of different drug regimens for TB, including short-course regimens, in individuals with silicosis
TB preventive treatment	• Effectiveness of TB preventive treatment, including that of short regimens, in silica-exposed individuals • Operational studies on how to improve uptake and adherence
Silica exposure cessation for preventive purposes	• Determination of silica exposure threshold that prevents excess risk of TB or recurrent TB • Risk of TB (or recurrent TB) associated with continuing silica exposure relative to ceasing exposure

CONCLUSION

The combined disease of silicotuberculosis has historically been subject to shifting interest and understanding – driven by burden of disease, concerns about compensation, medical exclusion, and loss of livelihood, and assignment of responsibility for treatment and prevention. The argument in this article is that one of the effects of the separation of silicosis and TB as individual diseases, to be considered and managed apart, has been the neglect of scientific exploration of their relationship and interaction in the late 20th and early 21st centuries.

Interest in phenotypes of combined disease waned in high-income countries with the decline in silicosis severity and incidence, and the introduction of effective treatment for TB – a stage prematurely believed to have been reached in South Africa. Failure to recognise subradiological silicosis in the classification of silicosis at the 1930 TB conference further contributed to the invisibility of combined disease, as did the South African migrant labour system, with the experience of miners leaving employment with silica-laden lungs or radiological silicosis lost to observation.

This overview has focused on the South African gold-mining industry, which is exceptional in some respects – such as a century-long management of a migrant labour system, the great depth of mining operations, and the size of local TB and HIV epidemics. However, the questions raised about silicotuberculosis apply also to other countries with large silica-exposed populations and high TB burdens, notably China and India, and to growing informal and small-scale mining in Africa.[38] A programme of research is needed in the relevant disciplines to pursue the unanswered questions, with funding sufficient to sustain research groups able to build the body of knowledge required for policy, clinical practice, and social justice.

DECLARATION

The author has prepared expert reports for plaintiff attorneys in silicosis legislation, including the relationship of silicosis to tuberculosis.

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REFERENCES

1. Ehrlich RI, Myers JE, te Water Naude J, Thompson ML, Churchyard GJ. Lung function loss in relation to silica exposure among South African gold miners. Occ Environ Med. 2011; 68(2):96-101. doi: 10.1136/oem.2009.048827.

2. Rupani MP. A mixed-methods study on impact of silicosis on tuberculosis treatment outcomes and need for TB-silicosis collaborative activities in India. Sci Rep. 2023; 13(1):2785. doi: 10.1038/s41598-023-30012-4.

3. Marinaccio A, Scarselli A, Gorini G, Chellini E, Mastrantonio M, Uccelli R, et al. Retrospective mortality cohort study of Italian workers compensated for silicosis. Occup Environ Med. 2006; 63(11):762–765. doi: 10.1136/oem.2006.027854.

4. Rosental P. Truncating a disease. The reduction of silica hazards to silicosis at the 1930 international labor office conference on silicosis in Johannesburg. Am J Ind Med. 2015; 58(Suppl 1):S6-S14. doi: 10.1002/ajim.22517.

5. Katz E. The White Death. Silicosis on the Witwatersrand Gold Mines 1886–1910. Johannesburg: Witwatersrand University Press; 1994.

6. Baldasseroni A, Carnevale F. The genesis and development of the scientific concept of pulmonary silicosis during the nineteenth century. In: Rosental P-A, editor. Silicosis: A World History. Baltimore: Johns Hopkins University Press; 2016. p. 30-63.

7. McCulloch J. Mining evidence: South Africa's gold mines and the career of A. J. Orenstein. Soc Hist Med. 2018; 31(1):61-78. doi:10.1093/shm/hkx001.

8. Cowie RL. What is silicosis? Proc Mine Medical Officers' Assoc. 1983; LXII(431):21-24.

9. Cowie RL. Silicosis, pulmonary dysfunction and respiratory symptoms in South African gold miners (MD thesis). Cape Town, South Africa: University of Cape Town; 1987.

10. Cowie RL. The epidemiology of tuberculosis in gold miners with silicosis. Am J Respir Crit Care Med. 1994; 150(5 Pt 1):1460-1462. doi: 10.1164/ajrccm.150.5.7952577.

11. Hnizdo E, Murray J, Sluis-Cremer GK, Glyn Thomas R. Correlation between radiological and pathological diagnosis of silicosis: an autopsy population based study. Am J Ind Med. 1993; 24(4):427-445. doi: 10.1002/ajim.4700240408.

12. Ehrlich R, Murray J, Rees D. Subradiological silicosis. Am J Ind Med. 2018; 61(11):877-885. doi: 10.1002/ajim.22909.

13. Hnizdo E, Murray J. Risk of pulmonary tuberculosis relative to silicosis and exposure to silica dust in South African gold miners. Occup Environ Med. 1998; 55(7):496-502. doi:10.1136/oem.55.7.496. Erratum in: Occup Environ Med. 1999 Mar; 56(3):215-216.

14. Corbett EL, Churchyard GJ, Clayton T, Herselman P, Williams B, Hayes R, et al. Risk factors for pulmonary mycobacterial disease in South African gold miners: a case-control study. Am J Respir Crit Care Med. 1999; 159(2):94-99. doi: 10.1164/ajrccm.159.1.9803048.
15. Corbett EL, Churchyard GJ, Clayton TC, Williams BG, Mulder D, Hayes RJ, et al. HIV infection and silicosis: the impact of two potent risk factors on the incidence of mycobacterial disease in South African miners. AIDS. 2000; 14(17):2759-2768. doi:10.1097/00002030-200012010-00016.
16. Spoor R. The terms of the settlement of the silicosis and TB class action – law firms. Politicsweb; 2018 May 3. Available from: https://www.politicsweb.co.za/archive/settlement-of-the-silicosis-and-tb-class-action (accessed 1 March 2024).
17. Bowmans. Trust Deed for the Tshiamiso Trust. Available from: https://www.tshiamisotrust.com/wp-content/uploads/2020/11/tshiamiso-trust-deed-2020.pdf (accessed 1 March 2024).
18. South Africa. Occupational Diseases in Mines and Works Act, 1973 (Act No. 78 of 1973). Available from: http://www.saflii.org/za/legis/consol_act/odimawa1973385.pdf (accessed 1 March 2024).
19. Ehrlich R, Barker S, Montgomery A, Lewis P, Kistnasamy B, Yassi A. Mining migrant worker recruitment policy and the production of a silicosis epidemic in late 20th century southern Africa. Ann Glob Health. 2023; 89(1):25, 1-12. doi: org/10.5334/aogh.4059.
20. McCulloch J, Miller P. Mining Gold and Manufacturing Ignorance: Occupational Lung Disease and the Buying and Selling of Labour in Southern Africa. London: Palgrave MacMillan; 2023.
21. Escreet BC, Cowie RL. Short-course chemotherapy for pulmonary tuberculosis. A 100-day interrupted regime. S Afr Med J. 1981; 60(25):951-955.
22. Cowie RL. Silicotuberculosis: long-term outcome after short-course chemotherapy. Tuberc Lung Dis. 1995; 76(1):39-42. doi: 10.1016/0962-8479(95)90578-2.
23. Southern African Development Community (SADC). Declaration on tuberculosis in the mining sector; 2012. Available from: http://www.stoptb.org/assets/documents/news/Declaration%20on%20Tuberculosis%20in%20the%20Mining%20Sector2012English.pdf (accessed 1 March 2024).
24. TB in the Mining Sector in Southern Africa (TIMS). Website. Available from: https://www.timssa.co.za/Resources/Reports.aspx (accessed 1 March 2024)
25. Maboso B, te Water Naude J, Rees D, Goodman H, Ehrlich R. Difficulties in distinguishing silicosis and pulmonary tuberculosis in silica-exposed gold miners: a report of four cases. Am J Ind Med. 2023; 66(4):339-348. doi:10.1002/ajim.23460.
26. Maboso BM, Moyo DM, Muteba KM, Govender VG, Barnes DF, Maama-Maime LBM, et al. Occupational lung disease among Basotho ex-miners in a large outreach medical assessment programme. Occup Health Southern Afr. 2020; 26(4):45-152. Available from: https://www.occhealth.co.za/_assets/articles/333/2094.pdf (accessed 2 March 2024).
27. Strachan AS, Simson FW. A preliminary study of the pathology of silicosis as seen on the Witwatersrand. In: International Labour Office (ILO). Silicosis. Records of the International Conference held at Johannesburg, 13–27 August 1930. London: PS King and Son, Ltd.; 1930. p 223-248. Available from: http://www.ilo.org/public/libdoc/ilo/ILO-SR/ILO-SR_F13_engl.pdf (accessed 1 March 2024).
28. Gardner LU. The similarity of the lesions produced by silica and by the tubercle bacillus. Am J Pathol. 1937; 13(1):13-24.
29. Benson L. Silicotuberculosisis. N Engl J Med. 1940; 223: 398-407. doi: 10.1056/NEJM194009122231102.
30. Pancoast HK, Pendergrass EP, Riddell AR, Lanza AJ, McConnell WmJ, Sayers RR, et al. Roentgenological appearances in silicosis and the underlying pathological lesions. Public Health Reports (1896–1970).1935; 50(31):989-996.
31. Du Toit FS. Tuberculo-silicosis. S Afr Med J. 1954; 28(40):845-850.
32. O'Neill RP, Robin ED. Relations of pneumoconiosis and pulmonary tuberculosis. Arch Environ Health. 1964; 8(6):873-881.
33. Davies JCA. Silicosis and tuberculosis among miners in South Africa during the 20th century. Occup Health Southern Afr. 2006; 12(5):11-19. Available from: https://www.occhealth.co.za/_assets/articles/166/622.pdf (accessed 2 March 2024).
34. McCulloch J. South Africa's Gold Mines and the Politics of Silicosis, Woodbridge: Boydell & Brewer; 2012.
35. Schepers GW. Silicosis and tuberculosis. Ind Med Surg. 1964; 33:381-399.
36. Solomon A, Rees D, Felix M, Venter M. Silicosis and tuberculosis: a proposed radiographic classification of tuberculosis to accompany the ILO International Classification of Radiographs of Pneumoconioses. Int J Occup Environ Health. 2000; 6(3):215-219. doi: 10.1179/oeh.2000.6.3.215.
37. Solomon A. Silicosis and tuberculosis: Part 2 – a radiographic presentation of nodular tuberculosis and silicosis. Int J Occup Environ Health. 2001; 7(1):54-57. doi: 10.1179/107735201800339605.
38. Moyo D, Ncube R, Kavenga F, Chikwava L, Mapuranga T, Chiboyiwa, N, et al. The triple burden of tuberculosis, human immunodeficiency virus and silicosis among artisanal and small-scale miners in Zimbabwe. J Environ Res Public Health. 2022; 19(21):13822. doi: 10.3390/ijerph192113822.