Silicosis disease burden in Zambian ex-copper miners continues to persist: Need for policy and programmatic reform to address ongoing challenges

Silicosis, first described by Hippocrates in 430 BC in metal diggers and one of the oldest recognised occupational lung diseases, remains a significant yet under-recognised public health challenge in sub-Saharan Africa.[1] Despite the preventable nature of this disease, recent evidence from Zambia confirms that former copper miners continue to have a prevalence of silicosis similar to figures documented over a decade ago. The study by teWaterNaude *et al.*[2] presents new data on silicosis prevalence in Zambian copper miners, reinforcing the urgent need for policy and programmatic reform in occupational health as part of broader public health measures to address ongoing health challenges.

Zambia's copper mining industry is not only a cornerstone of the national economy as the ongoing scramble for Africa's metals continues, to feed the contemporary digital electronic (e.g. computer production) and clean energy (e.g. electric cars, power generation) economy, but is also a long-standing source of occupational dust exposure. Mining in this region has historically been associated with silica dust levels that far exceed international occupational exposure limits, yet consistent and enforceable controls remain inadequate. This cross-sectional study by teWaterNaude *et al.*[2] in collaboration with Zambian colleagues evaluated 472 chest radiographs from ex-miners and reported a 8.3% prevalence of radiologically confirmed silicosis, with a concerning 3.4% of the total study population having advanced disease based on a category ≥2 according to the International Labour Organization (ILO) radiological classification for pneumoconioses. Notably, the prevalence has remained virtually unchanged from a 2012 study (unpublished), suggesting that preventive efforts over the past decade have failed to reduce the silica-related disease burden.

The clinical relevance of these findings extends beyond silicosis alone. Tuberculosis (TB), which is highly prevalent in the Southern African Development Community (SADC) region and was observed in 16.5% of these ex-miners, was strongly associated with silicosis (odds ratio 6.0; 95% confidence interval (CI) 3.0 - 11.9). This association is consistent with findings from a previous systematic review and meta-analysis showing a markedly increased risk of TB in workers with increased silica exposure or silicosis.[3] Importantly, the association persisted after adjusting for age, underscoring the biological interaction between silica exposure and TB pathogenesis, particularly in the context of southern Africa's migrant labour history and its link to HIV. Given the findings of a subsequent meta-analysis showing a similar positive relationship between silica exposure, silicosis and TB (pooled risk ratio 1.35, 95% CI 1.18 - 1.53),[4] the implications for TB control are profound. Mining communities have long been recognised as epicentres for TB in southern Africa. Zambia's first national TB prevalence survey, as teWaterNaude *et al.*[2] point out, reported the highest burden in the Copperbelt Province, home to most of the study subjects.[5] Occupational dust control must therefore be considered as a core component of national TB control efforts and not merely be restricted to TB case-finding activities.

An interesting finding of the current study was the relatively high prevalence of cardiomegaly, which was observed in 19.3% of ex-miners' chest radiographs. The positive association of this finding with length of service raises the possibility of previously unexamined non-occupational as well as known occupational contributors of this outcome. A nationwide population-based cohort study of 8 923 Taiwanese patients with pneumoconiosis and congestive cardiac failure showed an increased likelihood of coexisting coronary artery disease, hypertension and chronic obstructive pulmonary disease (COPD).[6] It is also well known that workers with chronic lung disease such as advanced pneumoconiosis, COPD, interstitial lung disease or post-TB lung disease are at an increased risk of developing pulmonary hypertension and presenting with cor pulmonale.[7] These findings suggest the need for integrated occupational and non-communicable disease surveillance in ageing ex-miner populations such as this one.

The findings of the current study also add to a growing body of African literature demonstrating persistently high rates of silicosis among miners. Comparatively, prevalence data in Zambian ex-copper miners are similar to those documented in South African (SA) gold miners, although lower than those reported for ex-miners in Lesotho and Botswana, where rates exceed 20%.[8] This variability is likely to reflect differences in commodity mined, mining methods, dust concentrations and dust silica content, and the representativeness of samples collected during occupational hygiene surveillance. Nonetheless, the presence of advanced silicosis of 41% among those with silicosis in the current Zambian study suggests significant past exposures.

The current Zambian legal framework does not include a statutory occupational exposure limit (OEL) for respirable crystalline silica, nor is there an enforceable national requirement for standardisation of gravimetric dust monitoring.[9] Previous dust measurements in Zambian copper mines demonstrated that between 53% and 78% of samples exceeded the widely recognised international health-based American Conference of Governmental Industrial Hygienists (ACGIH) OEL of 0.025 mg/m^3,[10] although more recent site-specific studies have reported lower concentrations.[9] However, variability in sampling methods and limited geographical scope make it difficult to determine whether dust control practices have improved systemically across all Zambian copper mines due to random and inconsistent practices of occupational hygiene surveillance as a result of inadequate legal enforcement.

An important element of the current study was the use of the ILO classification of radiographs by expert readers, which provided standardised diagnostic criteria widely used across epidemiological contexts globally. However, it would have been useful had the data from individual readings of both readers been presented separately and a measure of the degree of concordance between the readers computed and reported on. As with most studies, inherent limitations of observational studies can for various reasons preclude the ability

to demonstrate impactful findings. In this context, the use of a convenience sample and reliance on duration of employment as a proxy measure for exposure weakened the ability to make exposure-response inferences with sufficient power and confidence. However, these constraints are common in occupational health surveillance datasets collated in low- and middle-income countries (LMICs) and do not detract from the broader public health messages.

The findings of this study by teWaterNaude *et al.*[2] align with global calls for reinvigorated silicosis elimination strategies. The World Health Organization and ILO launched a Global Programme for the Elimination of Silicosis in 1995, yet progress has been slow, particularly in high-burden LMICs, including Zambia, where there is currently no state-supported silicosis elimination campaign. The failure to implement evidence-based control measures such as personal dust sampling (including respirable crystalline silica), enforceable OELs and effective medical surveillance, supported by appropriate actions including interventions aimed at dust suppression, continues to result in preventable disease in such contexts.[1]

This study makes a compelling case for a more comprehensive and co-ordinated occupational/public health response in Zambia. These measures could include establishment of a specific legally binding OEL for health-protective respirable crystalline silica levels of 0.025 mg/m^3; mandated and independently verified dust monitoring across all copper mines; strengthening of and expanded surveillance systems for current and ex-miners, including portable radiography and TB screening; investing in tools such as AI-enhanced chest screening as part of TB programmes to enable early identification of silicosis; and integration of occupational health data with national TB and non-communicable disease registries. A regional approach is also warranted. Zambia is not unique in facing these challenges, and the SADC offers a platform for harmonising occupational health legislation, developing training capacity for silicosis and TB detection, and promoting better dust control strategies.

In conclusion, the study by teWaterNaude *et al.*[2] provides a timely, evidence-based confirmation that silicosis continues to exact its toll on Zambian ex-copper miners. It demonstrates the urgent need for renewed public health attention to occupational dust exposure, not only to prevent chronic and irreversible lung disease but also to reduce TB burden in a region that remains disproportionately affected. The time to act on this evidence is *now*, before another generation of miners pays the price for continued inaction. It is probable that should this inaction persist, it would present a fertile ground for class action litigation being instituted against mine employers as we have witnessed across SA's asbestos, gold and more recently coal mining industries over the past three decades.[11]

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