

Silicosis and silicotuberculosis among respiratory hospital admissions: A cross-sectional survey in northern Tanzania

E Dennis,¹ MD; H Mussa,¹ MD; M P Sanga,¹ MD; P Howlett,^{2*} MB ChB, MSc ; G Nyakunga,^{3*} MD, MMed (Int Med)

¹ Kilimanjaro Christian Medical University College, Moshi, Tanzania

² National Heart and Lung Institute, Imperial College London, UK

³ Department of Internal Medicine, Kilimanjaro Christian Medical Centre, Moshi, Tanzania

* Joint last authors

Corresponding author: P Howlett (patrick.howlett@gmail.com)

Background. There is little evidence describing respiratory disease among 40.5 million small-scale miners worldwide.

Objectives. To describe the prevalence and clinical characteristics of adult respiratory inpatients with silicosis and silicotuberculosis in a tertiary hospital in Tanzania that serves a small-scale mining region.

Methods. In this retrospective, cross-sectional survey, patient files from admissions between 2010 and 2020 were opportunistically selected and included if a respiratory diagnosis had been made.

Results. Of 223 patients with respiratory conditions, 32 (14.3%; 95% confidence interval (CI) 10.0 - 19.6) were diagnosed with silicosis and 17 (7.6%; 95% CI 4.5 - 11.9) with silicotuberculosis. Mining was the most frequent occupation in those with silicosis ($n=15/32$; 46.9%) and silicotuberculosis ($n=15/17$; 88.2%). Of those with silicosis or silicotuberculosis, 26/49 (53.1%) were aged <45 years.

Conclusion. Our study suggests that silicosis and silicotuberculosis are common among male and female respiratory inpatients with occupational exposure. The study highlights the role of occupational exposures in respiratory disease in developing economies.

Keywords. Silicosis, tuberculosis, mining.

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Study synopsis

What the study adds. This retrospective, cross-sectional survey describes the prevalence of silicosis and silicotuberculosis among adult respiratory inpatients admitted to a tertiary hospital in northern Tanzania. It is the first study to describe the prevalence and characteristics of respiratory inpatients with silicosis and silicotuberculosis in a small-scale mining region of Africa. A high prevalence of silicosis (14.3%) and silicotuberculosis (7.6%) was found. Patients were often aged <45 years, and the majority required oxygen therapy.

Implications of the findings. The high prevalence of advanced silicosis and silicotuberculosis in miners presenting at a young age raises concerns about high occupational silica exposures and, importantly, suggests a need for community-based research, which our team is planning to undertake.

Occupational lung disease, particularly related to silica exposure, is an overlooked but preventable cause of chronic lung disease. In 2016, the Global Burden of Disease Study estimated 210 000 years of life lost due to silicosis.^[1] Silicosis is a direct effect of silica inhalation, but exposure is also associated with increased risks of tuberculosis, lung cancer and chronic obstructive pulmonary disease.^[2] Miners with silicosis have a four-fold higher risk of tuberculosis than those without silicosis, owing to immunological reasons, damaged lung architecture and shared environmental risks.^[3]

Small-scale mining is poorly defined, but broadly encompasses small, local companies mining borderline viable sites.^[4] Small-scale mining provides employment for an estimated 40.5 million people worldwide, but there is little evidence to describe the burden of respiratory diseases.^[4] Of an estimated 1.5 million miners in Tanzania,

the majority work in small-scale mines. Approximately 12 000 small-scale miners are employed at Mererani, a mining area in northern Tanzania that is the only source of the precious stone tanzanite. Tanzanite miners are exposed to significantly higher levels of silica than recommended exposure limits,^[5,6] leading to concerns regarding the miners' respiratory health. Local experience suggests that miners rarely wear personal protective equipment.

Kilimanjaro Christian Medical Centre (KCMC) is a large tertiary referral hospital in Moshi, Tanzania, serving the Mererani region. Anecdotal reports suggest that silicosis and mining-related lung diseases are a common cause of respiratory admissions.

In this retrospective, hospital-based survey, we aimed to describe the prevalence and clinical characteristics of silicosis and silicotuberculosis in adult medical inpatients in KCMC.

Methods

Study population

A hospital-based cross-sectional survey of patients admitted with respiratory conditions was conducted at KCMC.

Inclusion criteria were any patient with notes in the medical records department, aged ≥ 18 years, and admitted to KCMC during the 10-year period August 2010 - August 2020. Patients were required to have a primary lower respiratory diagnosis on discharge. Exclusion criteria included pregnant women and trauma.

We aimed for confidence intervals of $\pm 5\%$ around an estimated prevalence of 10% of respiratory admissions with silicosis. Using an exact binomial 95% distribution, we calculated that a sample size of 250 respiratory cases was needed.

Study procedures

Patient files were selected opportunistically from the hospital records department, aiming for a spread across all years and to reach 250 records. Primary diagnoses at discharge, as decided by the general physician in charge of the patient, were screened in tandem by authors ED, HM and MPS, who were medical students at the time of the study, with discrepancies resolved by discussion with the general physician (GN). Data entered electronically using *KoboToolbox* (2021) were reviewed for inconsistent or missing values.

Symptoms were recorded as present if noted on admission. Demographic details, HIV status and treatment modalities were recorded based on presence in the notes at any point. Occupation is routinely collected during the admission process at KCMC, so there were no missing values. Admission chest radiographs are routinely performed for respiratory patients, and findings from the radiologists' reports were recorded. KCMC is a tertiary hospital with full microbiology (including GeneXpert for tuberculosis) and laboratory services available. Patients with a diagnosis of silicosis currently being treated for tuberculosis were defined as having silicotuberculosis. Numerical data were summarised using medians and interquartile ranges, while categorical data were summarised using frequencies and percentages. An exploratory multivariable logistic regression analysis of risk factors for respiratory failure (defined as requiring oxygen on admission) among patients with silicosis or

silicotuberculosis was performed using *a priori* variables (age, sex, mining status, smoking, HIV status). All analyses were conducted using *Rstudio* with R version 3.6.3 (R Foundation for Statistical Computing, Austria). Ninety-five percent binomial exact confidence intervals (CIs) were calculated.

Ethical considerations

Ethics approval was obtained from the KCMC Research Ethics and Review Committee.

Results

Of 223 patients with respiratory conditions included in the study, 32 (14.3%; 95% CI 10.0 - 19.6) were diagnosed with silicosis and a further 17 (7.6%; 95% CI 4.5 - 11.9) with silicotuberculosis. Diagnoses of silicosis or silicotuberculosis were most frequent in the age group 30 - 44 years ($n=23/49$; 46.9%). A large proportion of respiratory patients ($n=122/223$; 54.7%) were current smokers. Two-thirds of patients had an HIV status recorded ($n=135/223$; 60.5%); among those who were tested, HIV was less frequent in those with silicosis (1/17; 5.8%) than in other groups.

Silicosis was the third most frequent respiratory diagnosis after pneumonia and tuberculosis, and silicotuberculosis the fifth

most frequent diagnosis (Fig. 1). The most frequent occupation in both the silicosis and silicotuberculosis groups was mining, and it was notable that miners presented almost exclusively with silicosis, silicotuberculosis or tuberculosis. Among 13 female patients diagnosed with silicosis or silicotuberculosis, the most frequent occupation was farming ($n=6/13$; 46.2%), followed by stone work ($n=4/13$; 30.8%) and mining ($n=3/13$; 23.1%). Although stone work, road construction, the steel industry and sandblasting are potentially less frequent occupations in the general population, they appeared relatively common among respiratory inpatients.

Respiratory symptoms across silicosis, silicotuberculosis and other respiratory diagnosis groups were broadly similar (Table 1). In both the silicosis and silicotuberculosis groups, shortness of breath and cough were almost universally present, and chest pain, night sweats, fever and weight loss were common. The frequent presence of peripheral oedema and cyanosis in the silicosis and silicotuberculosis groups suggests that right heart failure was common. In keeping with the diagnoses, radiographic findings of fine nodularity in the upper zones and coalescence of nodules with hilar infiltration were common in both the

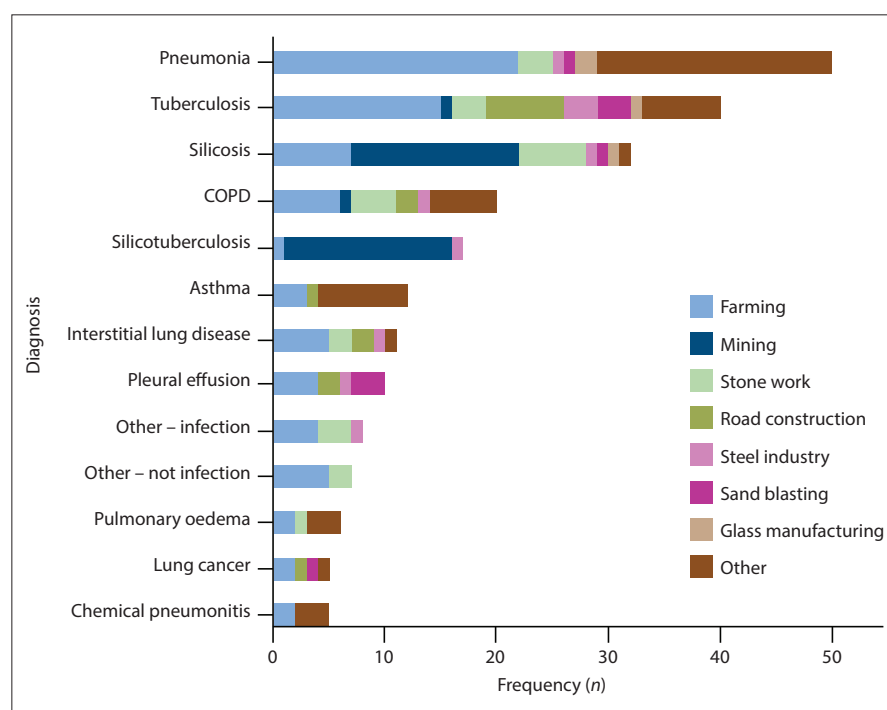


Fig. 1. Bar chart of adult respiratory inpatient diagnoses by occupation (N=223). (COPD = chronic obstructive pulmonary disease.)

Table 1. Clinical characteristics of adult respiratory inpatients with silicosis and silicotuberculosis*

	Silicosis (n=32), n (%)	Silicotuberculosis (n=17), n (%)	Other respiratory inpatients (n=174), n (%)	Total (N=223), n (%)
Age (years)				
15 - 29	2 (6.2)	1 (5.9)	50 (28.7)	53 (23.8)
30 - 44	14 (43.8)	9 (52.9)	55 (31.6)	78 (35.0)
45 - 59	12 (37.5)	5 (29.4)	34 (19.5)	51 (22.9)
60 - 74	2 (6.2)	2 (11.8)	24 (13.8)	28 (12.6)
75 - 89	2 (6.2)	0	11 (6.3)	13 (5.8)
Gender				
Female	11 (34.4)	2 (11.8)	48 (27.6)	61 (27.4)
Male	21 (65.6)	15 (88.2)	126 (72.4)	162 (72.6)
HIV status				
Negative	16 (50.0)	10 (58.8)	84 (48.3)	110 (49.3)
Positive	1 (3.1)	2 (11.8)	22 (12.6)	25 (11.2)
Missing or not recorded	15 (46.9)	5 (29.4)	68 (39.1)	88 (39.5)
Smoker				
Yes	16 (50.0)	4 (23.5)	93 (53.4)	123 (55.2)
No	16 (50.0)	13 (76.5)	81 (46.6)	100 (44.8)
Symptoms				
Shortness of breath	31 (96.9)	17 (100)	157 (90.2)	205 (91.9)
Cough	32 (100)	17 (100)	170 (97.7)	219 (98.2)
Wheeze	19 (59.4)	6 (35.3)	73 (42.0)	98 (43.9)
Weight loss	23 (71.9)	13 (76.5)	89 (51.1)	125 (56.1)
Chest pain	31 (96.9)	15 (88.2)	153 (87.9)	199 (89.2)
Fever	15 (46.9)	9 (52.9)	94 (54.0)	118 (52.9)
Night sweats	26 (81.2)	14 (82.4)	88 (50.6)	128 (57.4)
Cyanosis	13 (40.6)	3 (17.6)	48 (27.6)	64 (28.7)
Lower limb oedema	12 (37.5)	8 (47.1)	45 (25.9)	65 (29.1)
Radiographic findings				
Fine nodularity in the upper zone of the lungs	20 (62.5)	11 (64.7)	13 (7.5)	44 (19.7)
Coalesced nodules with hilar infiltration	7 (21.9)	3 (17.6)	6 (3.4)	16 (7.2)
Miliary patterns	3 (9.4)	2 (11.8)	27 (15.5)	32 (14.3)
Other findings	2 (8.7)	1 (5.9)	128 (73.6)	131 (58.7)

*No variables had missing values except for HIV status.

silicosis and silicotuberculosis groups, but markedly reduced in other respiratory diagnoses.

In addition to antituberculosis medications, the majority of patients with silicosis and silicotuberculosis received steroids ($n=39/49$; 79.6%) and antibiotics ($n=42/49$; 85.7%). Of note, 16/17 (94.1%) of patients on antituberculosis treatment received adjunctive steroids. The majority ($n=31/49$; 63.3%) required oxygen on admission. Exploratory logistic regression analysis found that the main risk factor for respiratory failure among those with silicosis or silicotuberculosis was being a miner (adjusted odds ratio 14.2; 95% CI 1.58 - 213; $p=0.03$).

Discussion

Although evidence suggests that silica dust exposure is high, the burden of silicosis among small-scale miners in Tanzania is unclear. Our retrospective, cross-sectional inpatient study found a high prevalence of silicosis (14.3%) and silicotuberculosis (7.6%) among respiratory inpatients in a tertiary hospital in northern Tanzania. Mining was the main occupation in patients with silicosis and silicotuberculosis. Over

half of the patients with silicosis or silicotuberculosis presented under the age of 45 years (53.1%), and the majority (63.3%) required oxygen therapy.

To the best of our knowledge, there is no comparable study of hospital silicosis or silicotuberculosis prevalence in a small-scale mining area. In South Africa, workplace-based estimates range from 1.7% to 36.6% in current and ex-goldminers.^[7-9] Although our study may not be generalisable to the wider local mining population, the high proportion of inpatients points to a large workforce burden of disease. This concern is supported by high levels of silica exposure in local mines.^[5,6]

Our data suggest that a large proportion of young patients with silicosis and silicotuberculosis present with respiratory failure. We are mindful, however, of competing sources of bias regarding this conclusion. On the one hand, our cases may over-represent the most advanced and youngest cases, who are motivated to seek care in a tertiary facility. Conversely, however, our cases may not be captured by mine-based surveys that are prone to the healthy worker effect.

Nevertheless, our findings raise the concern that individuals from the local area with high silica exposure^[5,6] may be presenting at younger ages than expected with advanced disease.

Elementary occupations (those involving routine tasks, often hand-held tools and a degree of physical effort) in Tanzania represented 10.9% of all employment in 2014.^[10] The comparatively high frequency of stone work, road construction, steel industry and sandblasting workers in our study suggests that these may be over-represented among inpatients with respiratory disease. We found that a third (34.4%) of patients with silicosis were women, in keeping with estimates that 40 - 50% of small-scale miners are women.^[11]

Importantly, there appears to be a missed opportunity for HIV testing, with 39.5% of patients having no HIV status recorded. Rates of smoking also appear very high among both silicosis-related and non-silicosis-related diseases (54.7%), highlighting the vital role of anti-tobacco policies. The clinical and radiological similarities between silicosis and silicotuberculosis highlight the practical challenges of diagnosis.

Our study has significant limitations. First, we did not have a standardised method for selecting patient notes, meaning that our sample may not be representative of the underlying population. Second, as the hospital charges user fees it is possible that the prevalence of miners is over- or under-estimated based on their ability to pay for their care, relative to other patients. Third, the infrequent use of advanced diagnostics such as bronchoscopy and chest computed tomography means there is a risk of misclassification bias regarding diagnosis. Finally, we did not record patients' residence or their location of work. While the largest small-scale mining population is in the Mererani region, there are other small-scale and large-scale mining locations in the catchment area of KCMC with high exposures.^[6]

Conclusions

Our hospital-based study found a high prevalence of young inpatients with silicosis and silicotuberculosis, who often presented with respiratory failure. This finding raises concerns regarding high occupational dust exposure and supports workplace studies of silica-related disease in exposed industries, such as artisanal and small-scale mining, in northern Tanzania. More broadly, the findings highlight the important role of occupational exposures in the growing burden of chronic lung diseases in developing economies.

Declaration. The research for this study was done in partial fulfilment of the requirements for ED, HM and MPS's MD degrees at Kilimanjaro Christian Medical University College, Tanzania.

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Author contributions. HM, ED, MPS: conceptualisation, methodology, project administration, data collection, writing – original draft preparation. PH: data curation, formal analysis, visualisation, writing – original draft preparation. GN: supervision, writing – review and editing.

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Conflicts of interest. None.

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