# AN EVALUATION OF MORTALITY RATES AND THEIR DETERMINANTS IN A COHORT OF FORMER ASBESTOS MINERS IN SOUTH AFRICA

**Yumna Williams**[1], Rodney Ehrlich [1], Jim teWaterNaude[1] Shahieda Adams[1]
[1]Division of Occupational Medicine, University of Cape Town, Western Province, South Africa

## BACKGROUND

- Asbestos minerals are **natural silicates** characterised by a **fibrous structure** and **widely used across industries.**
- **South Africa had a thriving asbestos industry in the 1970s** and was a **leading global producer.** [1]
- A **causal link** between occupational asbestos exposure and a spectrum of pulmonary diseases including pneumoconiosis and mesothelioma is well-documented (Figure 1). [2-15]
- **International research** has demonstrated increased all-cause and cause-specific Standardised Mortality Ratios (SMRs) among asbestos-exposed workers. [2-15]
- However, **the mortality experience of former asbestos miners in South Africa remains poorly studied.**
- T**he all-cause mortality among a cohort of former South African asbestos miners** was investigated.

Chrysotile asbestos

Amosite asbestos

Crocidolite asbestos

## METHODOLOGY

- A **retrospective cohort study** was conducted on **11343 former asbestos miners** between 01 January 2004 and 21 March 2023.
- **Significant differences in predictor variables, by vital status,** were assessed with Chi-squared tests and results reported as p-values.
- **Standardised Mortality Ratios (SMRs)** were calculated using the general South African population as the reference, **matched by age, sex, and calendar year.**
- **A Cox proportional hazards model was employed to identify predictors** of all-cause mortality.
- Survival time was computed as the time of entry into the Inyosi database to the date of death or censoring (21 March 2023).
- **Kaplan-Meier survival curves**, stratified by $FEV_1$ and FVC z-scores (low vs. normal), were used to visualise differences in survival probability.
- **Annual SMRs and Crude Mortality Rates (CMRs)** were calculated to assess temporal trends in mortality.
- **Ethics approval** was obtained from UCT's Human Research Ethics Committee (HREC ref: 625/2024).

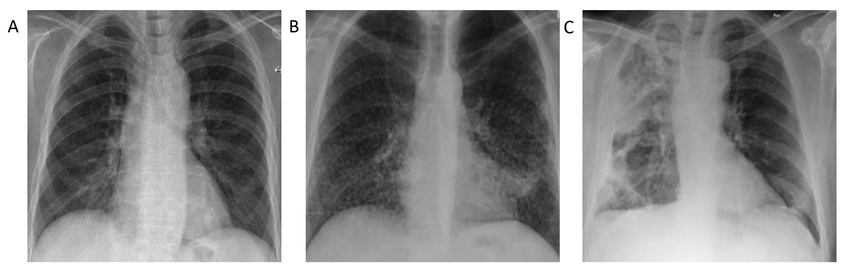


**Figure 1**: A comparison between a normal CXR (A) and a CXR showing asbestos-related pneumoconiosis (B) and mesothelioma (C).

## RESULTS

- The cohort's **median age** was **53.1 years**, **82.8% were males**, **43.1% were crocidolite-exposed** and **75.8% were employed aboveground.**
- **The cohort's all-cause mortality exceeded that of the general population by 4%** (SMR=1.04; 95% CI: 1.01-1.07), with **43.7% of deaths occurring before 55 years** and **clear sex disparities.**
- **ILO profusion category was a strong, dose-responsive predictor of mortality**, with adjusted hazard ratios (aHRs) increasing from 1.13 (95% CI: 1.05–1.23) in ILO category 1 to 2.34 (95% CI: 1.52–3.58) in ILO category 3.
- A **negative correlation** between higher ILO profusion categories and lung function was observed (Figure 2).
- **Reduced lung function significantly and independently predicted mortality** (Figure 3) with $FEV_1$ demonstrating stronger predictive ability (aHR=1.60; 95% CI:1.41-1.81 and aHR=1.26: 95% CI: 1.12-1.42, respectively, for z-scores less than -3.0).
- About **56.7% of those with costophrenic angle obliteration had abnormally low FVC z-scores**, with 47.9% showing moderate to severe reductions(below -2.0). This impaired lung function may have contributed to the increased risk of mortality in this subset (Figure 4)
- Other significant predictors (Table 1) were **a BMI less than 18.5 kg/m2** (aHR=1.46; 95% CI: 1.35-1.58), a **history of previous smoking** (aHR=1.43; 95% CI: 1.35-1.53), **costophrenic angle obliteration** (aHR=1.27; 95% CI: 1.14-1.41).
- Over the study period, **SMRs initially rose, plateaued** between 2011 and 2018, and **subsequently declined** barring a presumed 2021 COVID-19 related spike (Figure 5).

**Table I: Demographic, occupational and clinical predictors of mortality in Asbestos and Kgalagadi Trust claimants between 2004 and 2023**

| Predictor | Hazard Ratio $_{Adj}$ | 95% CI | p-value |
|---|---|---|---|
| **Age on entry to cohort (years)** | | | |
| *<35 | - | - | - |
| 35 – 44.9 | 1.15 | 0.68 – 1.96 | 0.598 |
| 45 - 54.9 | 1.50 | 0.89 – 2.55 | 0.129 |
| **55 - 64.9** | **2.60** | **1.54 – 4.41** | **0.000** |
| **≥ 65** | **4.46** | **2.63 – 7.58** | **0.000** |
| **Biological Sex** | | | |
| *Female | - | - | - |
| **Male** | **1.20** | **1.10– 1.31** | **0.000** |
| **Cigarette Smoking Status** | | | |
| *Never | - | - | - |
| **Previous** | **1.43** | **1.35 – 1.53** | **0.000** |
| **Type of Asbestos Exposure** | | | |
| *Chrysotile only | - | - | - |
| Crocidolite only | 1.08 | 1.00 – 1.17 | 0.058 |
| Amosite only | 0.75 | 0.59 – 0.96 | 0.022 |
| Mixed | 1.14 | 0.83 – 1.57 | 0.414 |
| **Unspecified** | **1.21** | **1.10 – 1.32** | **0.000** |
| **Nature of Mine Work** | | | |
| *Underground only | - | - | - |
| **Aboveground only** | **1.16** | **1.07 – 1.25** | **0.000** |
| Unspecified | 1.05 | 0.85 – 1.30 | 0.653 |
| **Time in Employment (years)** | | | |
| *0 - 5 | - | - | - |
| 5 - 10 | 0.85 | 0.75 – 0.96 | 0.007 |
| 10 -15 | 0.81 | 0.62 – 1.08 | 0.147 |
| >15 | 1.27 | 0.91 – 1.76 | 0.157 |
| Unknown | 1.06 | 0.98 – 1.15 | 0.165 |
| **BMI at baseline (kg/m²)** | | | |
| *Normal | - | - | - |
| **Underweight** | **1.46** | **1.35 – 1.58** | **0.000** |
| Overweight | 0.89 | 0.82 – 0.97 | 0.006 |
| Obese | 1.03 | 0.93 – 1.13 | 0.609 |
| **ILO Profusion Category** | | | |
| *Category 0 | - | - | - |
| **Category 1** | **1.13** | **1.05 – 1.23** | **0.002** |
| Category 2 | 1.23 | 1.00 – 1.51 | 0.054 |
| Category 3 | **2.34** | **1.52 – 3.58** | **0.000** |
| **Pleural Plaques** | | | |
| *Absent | - | - | |
| Present | 0.85 | 0.79-0.92 | 0.000 |
| **Costophrenic angle obliteration** | | | |
| *Absent | - | - | |
| **Present** | **1.27** | **1.14 – 1.41** | **0.000** |
| Diffuse Pleural Thickening | | | |
| *Absent | - | - | - |
| Present | 1.13 | 0.99 – 1.28 | 0.061 |
| **$FEV_1$ z-score** | | | |
| *Normal | - | - | - |
| Mildly low | 1.02 | 0.92 – 1.13 | 0.712 |
| **Moderately low** | **1.13** | **1.02 – 1.24** | **0.014** |
| **Severely low** | **1.60** | **1.41 – 1.81** | **0.000** |
| **FVC z-score** | | | |
| *Normal | - | - | - |
| Mildly low | 1.06 | 0.95 – 1.18 | 0.302 |
| Moderately low | 1.06 | 0.97 – 1.17 | 0.220 |
| **Severely low** | **1.26** | **1.12 – 1.42** | **0.000** |
| **Asbestos-Related Disease Category** | | | |
| *No ARD | - | - | - |
| ARD 1 | 1.14 | 1.04 – 1.25 | 0.004 |
| ARD 2 | 1.16 | 0.98 – 1.37 | 0.076 |
| **ARD 3** | **3.85** | **2.47 – 6.01** | **0.000** |
| **ARD 4** | **6.35** | **5.42 – 7.45** | **0.000** |
| **Not determined** | **1.37** | **1.10 – 1.70** | **0.005** |

* Reference value

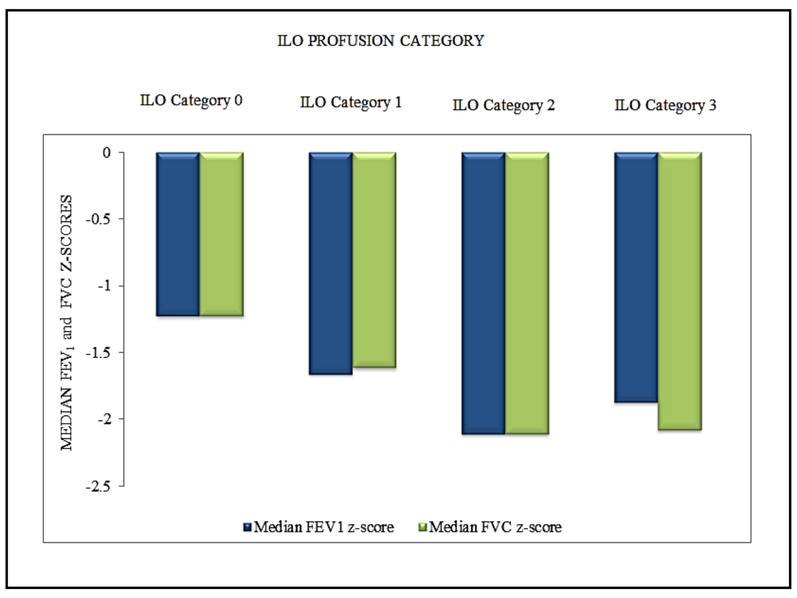


**Figure 2:** Declining Median $FEV_1$ and FVC z-scores across the main ILO profusion categories

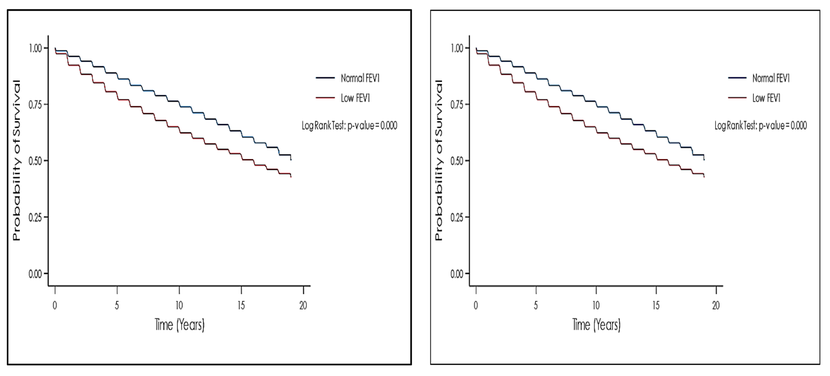


**Figure 3**: Kaplan-Meier plot comparing the survival probability between participants with and without a low $FEV_1$ z-score or FVC z-score

## RESULTS

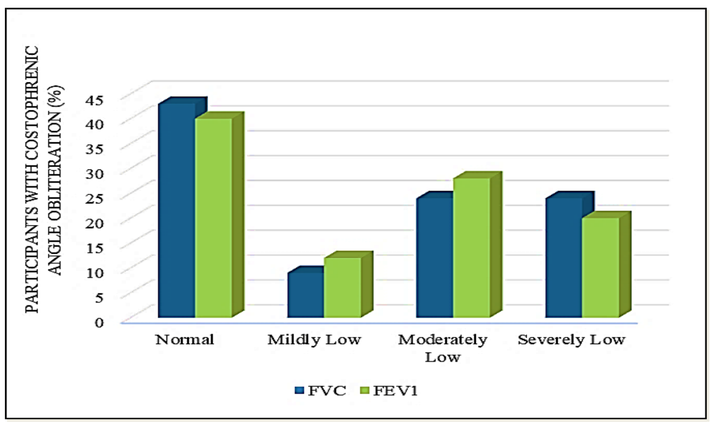


**Figure 4:** Spirometry findings in participants with costophrenic obliteration

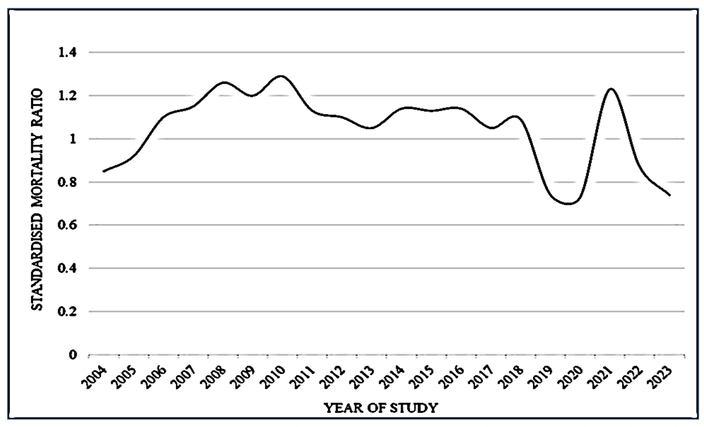


**Figure 5:** Standardised mortality ratios among Asbestos and Kgalagadi Relief Trust claimants for each year of the study period from 2004 to 2023

## DISCUSSION

- **The lower-than-expected SMR** (4.0%) is likely due to survivorship bias, inconsistencies in data capturing and shorter duration of employment.
- **Demographic predictors of mortality** i.e. age, biological sex and smoking history **aligned with international research.**
- **Occupational factors demonstrated limited predictive ability** with no association observed with fibre type and employment duration.
- **Radiological and reduced lung function** emerged as the strongest predictors of mortality.

## CONCLUSION

- This **large-scale, long-term cohort study** examining mortality among historically marginalised South African asbestos miners and thus **presents novel data.**
- The study reflects **overall mortality trends** and not solely those attributable to asbestos-related diseases.
- The identification of clinical predictors contributes to a **better understanding of post-employment health consequences** of asbestos exposure.
- **Incomplete data** limited the interpretation of mortality patterns in this cohort, preventing firm conclusions.
- Radiologic and spirometric findings were key predictors of mortality, offering **potential for risk stratification and targeted care.**
- Such interventions include **early management and prevention of respiratory complications and smoking cessation,** which could mitigate mortality risk.

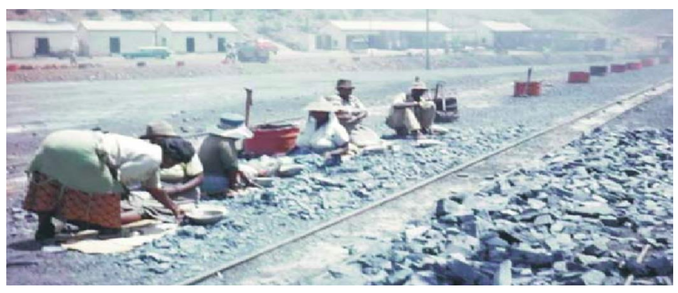

**Figure 6**: Females engaged in aboveground "cobbing" which entailed the separation of asbestos fibres by hand

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## CONFLICT OF INTEREST

- The authors declare no conflict of interest.

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## REFERENCES