



Occupational lung disease surveillance in South African miners at autopsy

3rd Annual mine dust conference



MINING INDUSTRY
OCCUPATIONAL
SAFETY & HEALTH



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BACKGROUND

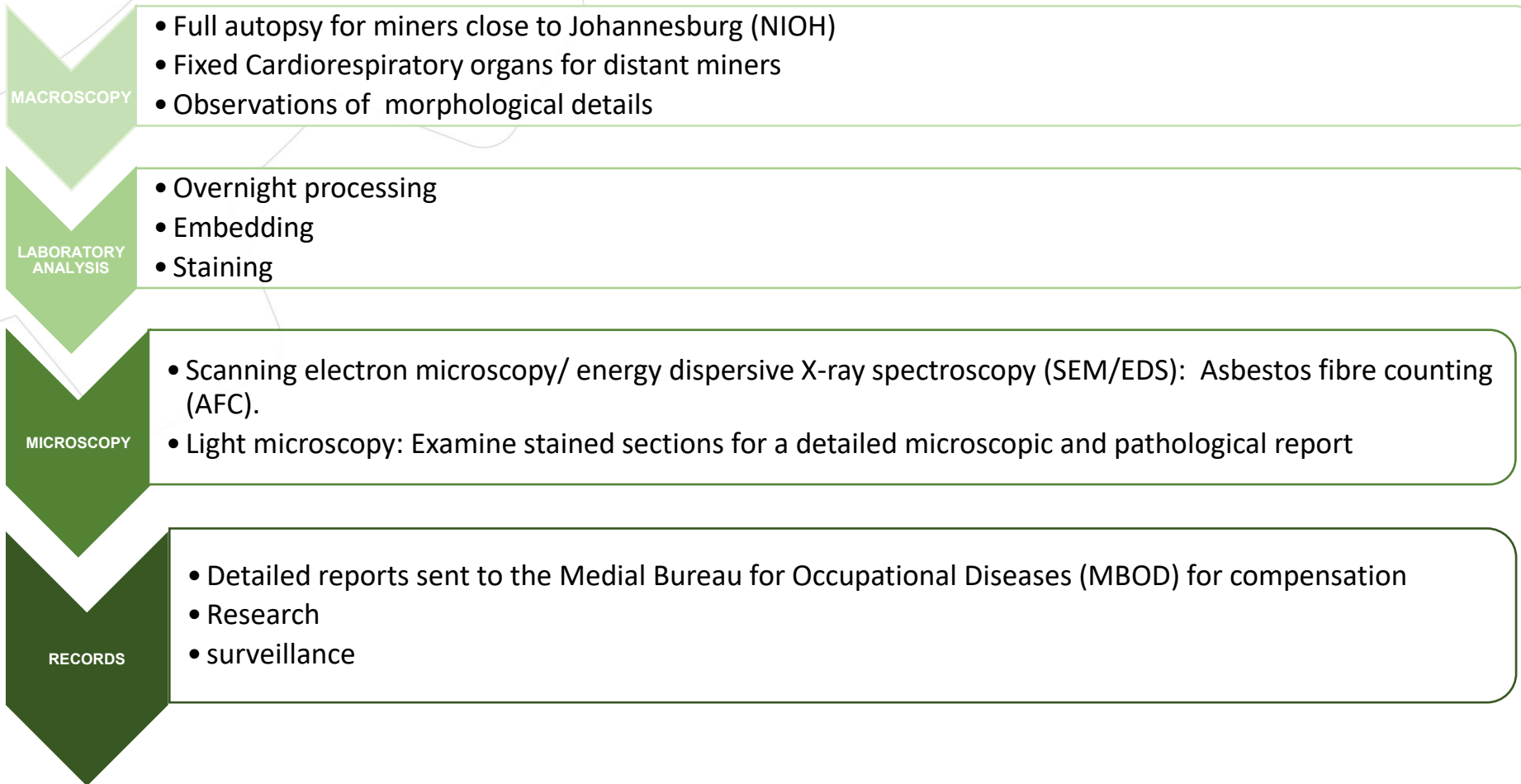
- ▶ The NIOH, Pathology Division support a statutory requirement to analyse the cardiorespiratory organs of deceased miners and ex-miners of controlled mines.
 - ▶ Occupational Diseases in Mines and Works Act (ODMWA), 1973 (Act 78 of 1973).¹
- ▶ Provided that the miner was employed in controlled mines and works (list held by DMP) and worked in South Africa and the next of kin gives consent.
- ▶ The autopsy findings are used to determine the presence of compensable occupational respiratory diseases.

- ▶ Since 1975, the pathological findings from the miners autopsy examinations were recorded on the PATHAUT database at NIOH.
- ▶ Gender has been recorded since 2005.
- ▶ A detailed report on each case examined is sent to the Medical Bureau for Occupational Diseases (MBOD).
 - ▶ Cases certified as having a compensable disease are then referred to the Compensation Commissioner's office, where the payment for compensation is managed.



- ▶ NIOH produces annual PATHAUT surveillance reports
- ▶ conditions reported on are pulmonary tuberculosis (PTB), silicosis, emphysema, asbestosis, dust-related massive fibrosis, coal workers pneumoconiosis, mixed dust pneumoconiosis, primary lung cancer and mesothelioma.
- ▶ A breakdown on demographic data such as age, race, gender, working (exposure) histories and province from which the organs were sent are covered.
- ▶ Previous reports can be accessed at:
<https://www.nioh.ac.za/pathology-disease-surveillance-reports/>

NIOH PATHOLOGY PROCESS

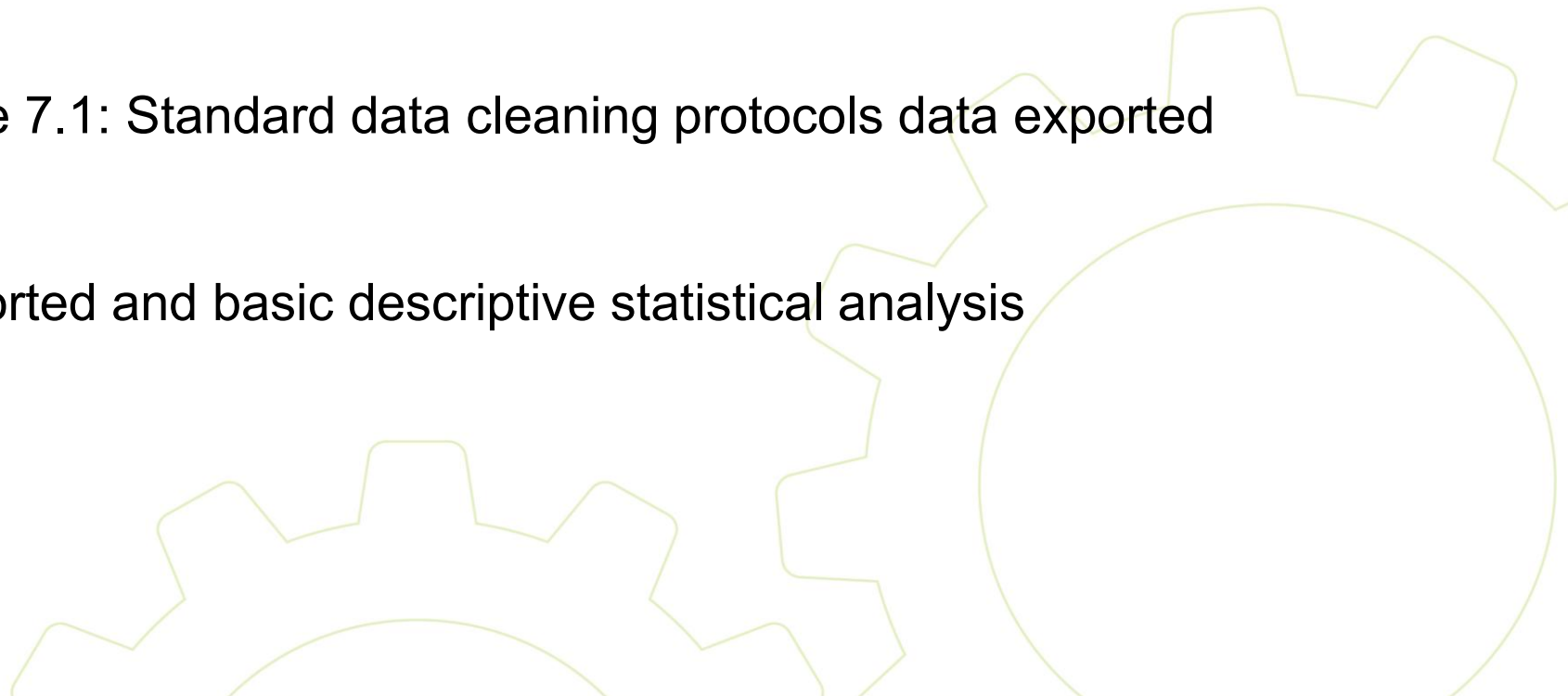


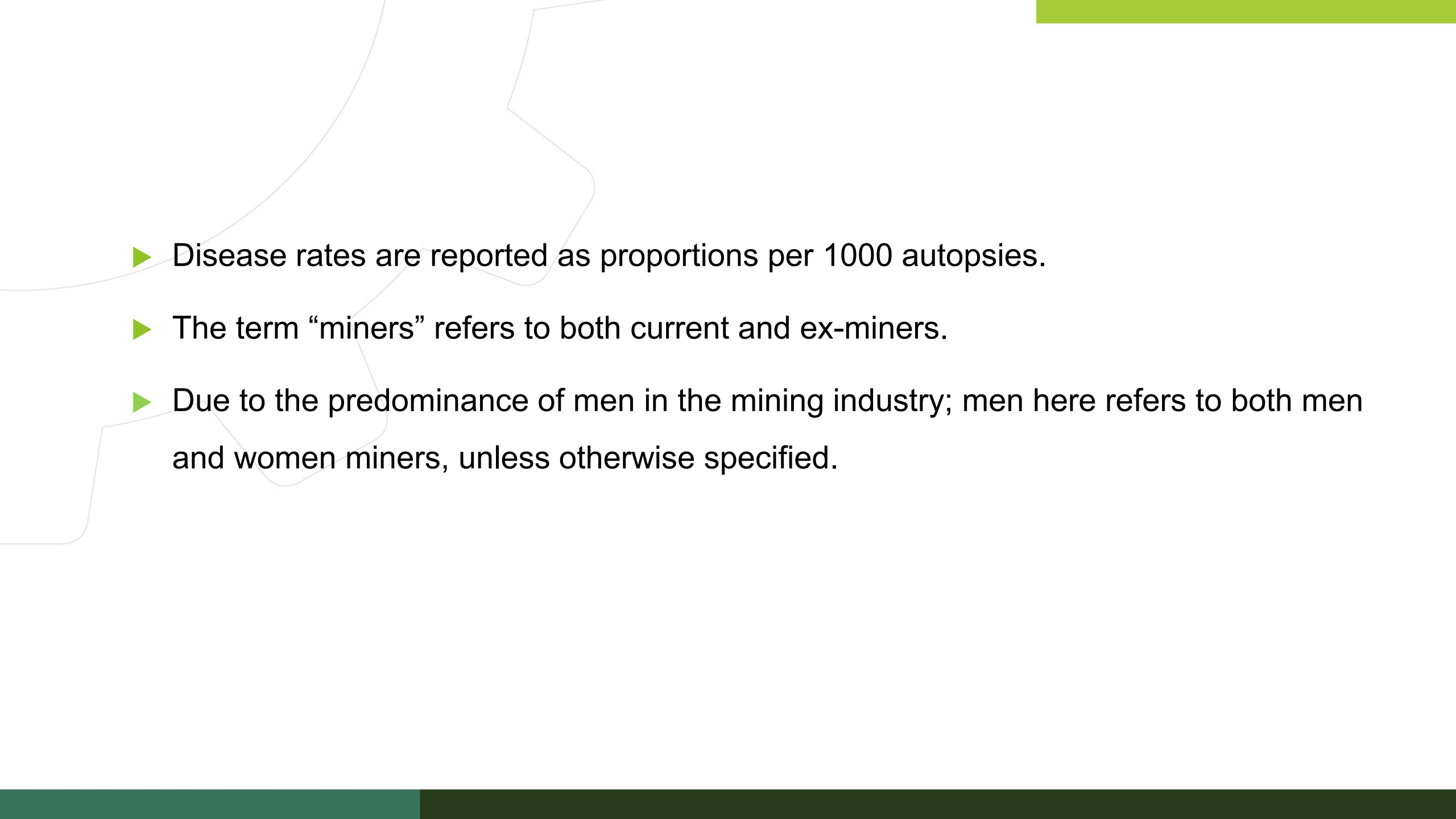


DATA MANAGEMENT AND ANALYSIS:



- ▶ Pathology Automation System (PATHAUT) database: Stores data – data exported to SAS.
- ▶ SAS Enterprise Guide 7.1: Standard data cleaning protocols data exported to CSV
- ▶ STATA 16: Data imported and basic descriptive statistical analysis conducted.



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- ▶ Disease rates are reported as proportions per 1000 autopsies.
 - ▶ The term “miners” refers to both current and ex-miners.
 - ▶ Due to the predominance of men in the mining industry; men here refers to both men and women miners, unless otherwise specified.



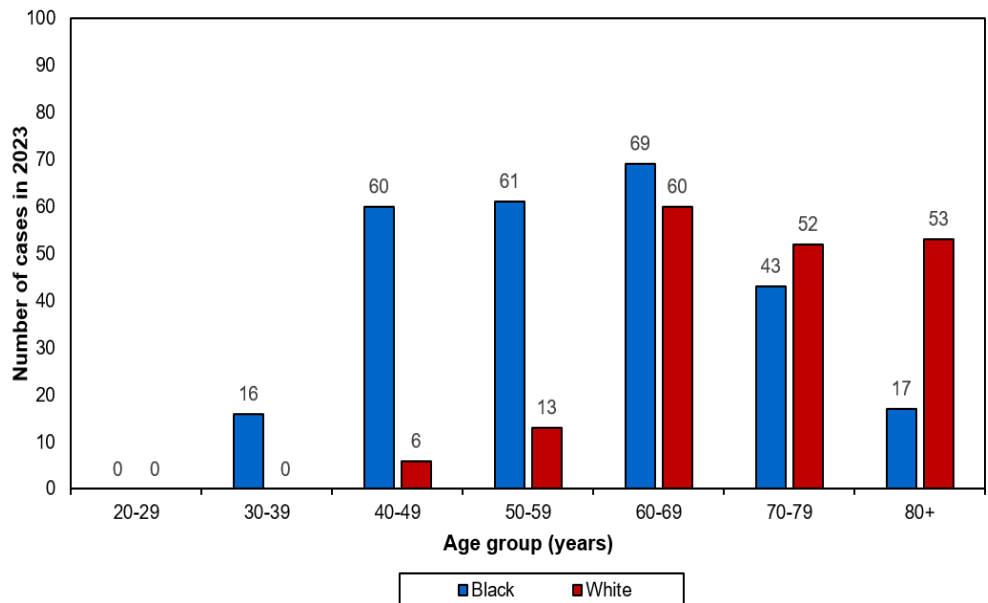
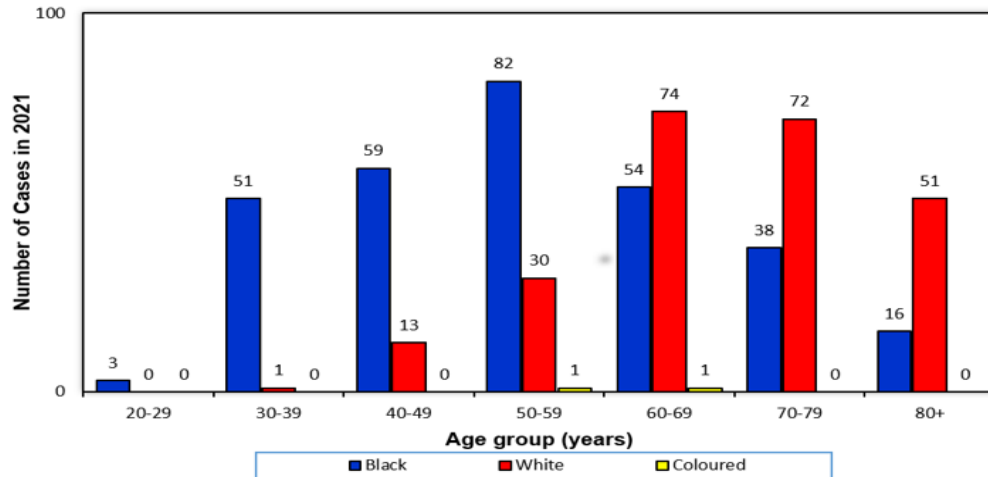
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RESULTS AND DISCUSSION

DEMOGRAPHIC DATA



2021	BLACKS		WHITES		COLOURED		TOTAL
	Males	Females	Males	Females	Males	Females	
	49.5%	6.0%	44.1%	0	0.4%	0	546
	Mean age		55.2 years		69.4 years		62 years
	Mean work duration		15 years		22 years		18 years

2022	BLACKS		WHITES		COLOURED		TOTAL
	Males	Females	Males	Females	Males	Females	
	47.1%	7.3%	45.6%	0	0	0	410
	Mean age		57.9 years		71.6 years		64 years
	Mean work duration		14 years		23 years		18 years

2023	BLACKS		WHITES		COLOURED		TOTAL
	Males	Females	Males	Females	Males	Females	
	51.8%	7.3%	40.9%	0	0	0	450
	Mean age		58.7 years		72.0 years		64 years
	Mean work duration		14 years		19 years		16 years

Figure 1. Demographic characteristics of miners (2021-2013)

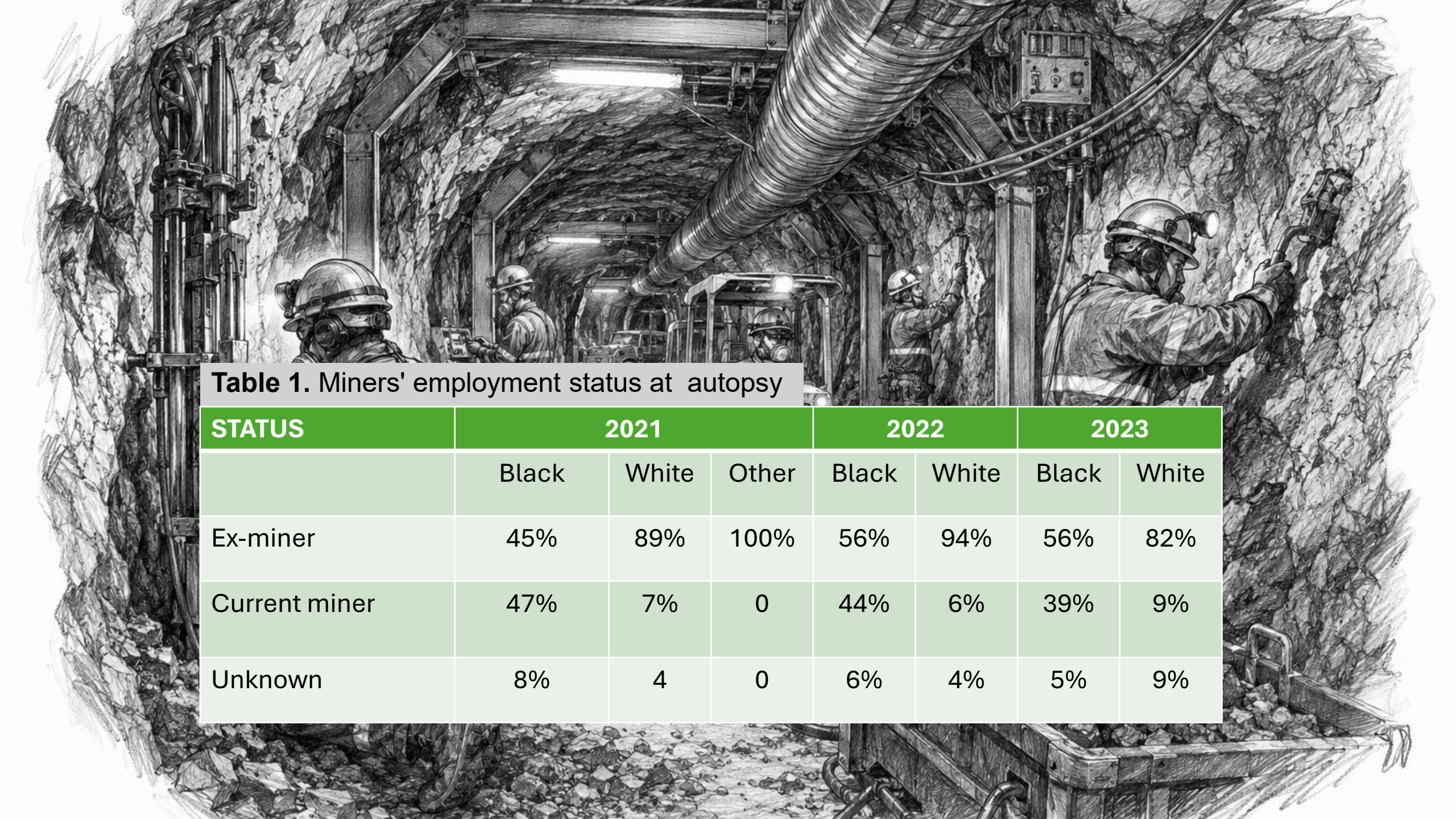


Table 1. Miners' employment status at autopsy

STATUS	2021			2022		2023	
	Black	White	Other	Black	White	Black	White
Ex-miner	45%	89%	100%	56%	94%	56%	82%
Current miner	47%	7%	0	44%	6%	39%	9%
Unknown	8%	4	0	6%	4%	5%	9%



COMMODITY

Table 2. Percentages of autopsies by commodity (2021 - 2023)

	Gold	Platinum	Coal	Asbestos	Copper	Manganese	Other
2021	61.7%	15.9%	1.6%	12.1%	0.5%	2.0%	6.2%
2022	62.9%	14.4%	2.4%	11.7%	0.2%	2.0%	6.4%
2023	60.2%	10.4%	4.0%	17.1%	0.2%	2.7%	5.4%

DISTRIBUTION OF AUTOPSIES BY PROVINCE

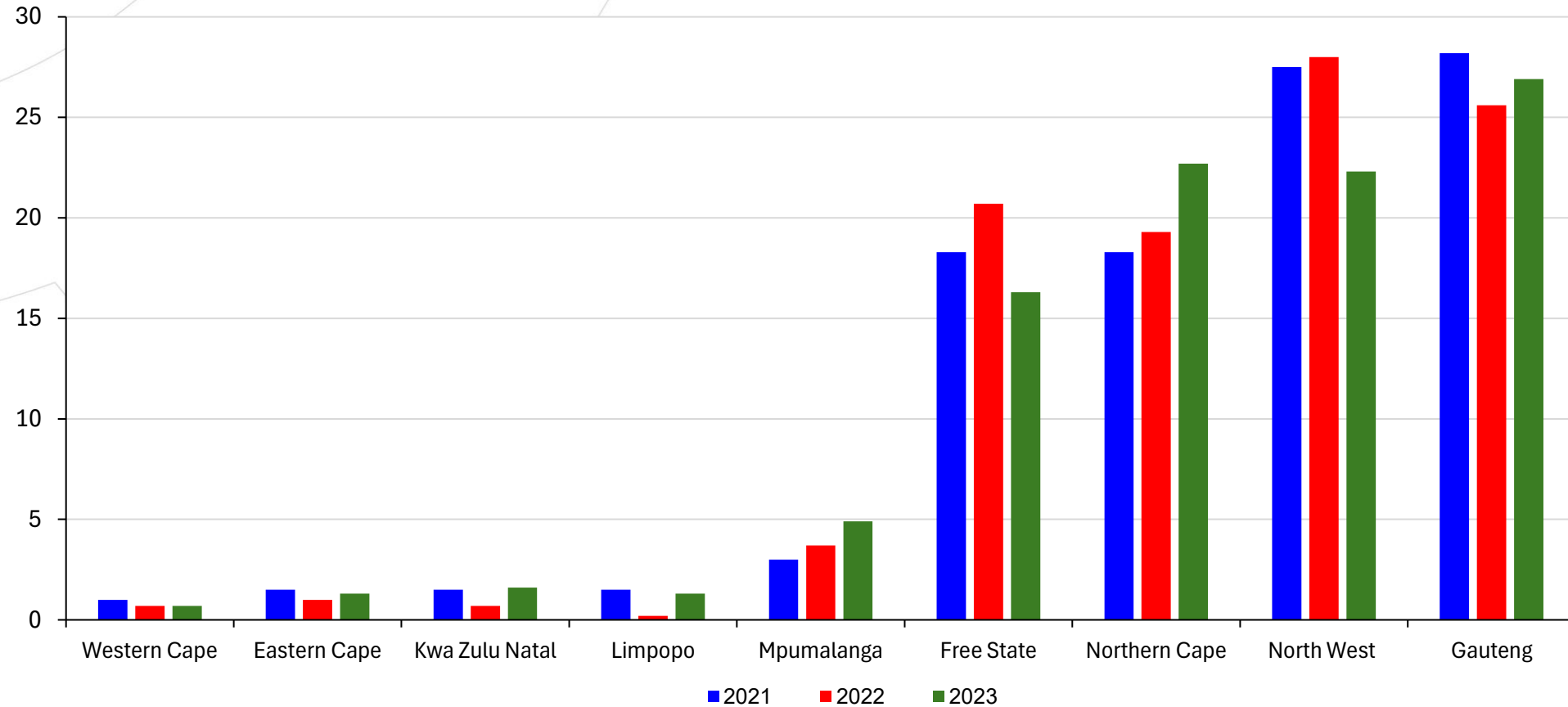


Figure 2. Percentage of cases received by province where death occurred (2021 - 2023)

ACTIVE PULMONARY TUBERCULOSIS

- ▶ Pulmonary tuberculosis is a key occupational disease in the South African mining industry.
 - ▶ Driven by occupational exposures e.g. silica dust exposure, confined working environments and high HIV prevalence among miners.

Pathaut Black Miners 1990 TB rate = 60/1000 autopsies

Pathaut Black miners 2023 TB rate = 177/1000 autopsies

- ▶ 2023 = 136 active TB/1000 miner autopsies – South Africa crude TB death rate in men was $\approx 50/1000$ deaths (Stats SA)
- ▶ The majority of active PTB cases between 2021 – 2023 were seen in gold miners, followed by platinum miners and asbestos miners (see reports).
- ▶ A higher percentage of current miners were diagnosed with active TB compared to ex-miners.

- Black and White gold miners, despite the reduction of active TB since the mid 2000s, rates of active PTB remain well above the rates seen in the 80s and 90s in miners and ex-miners.

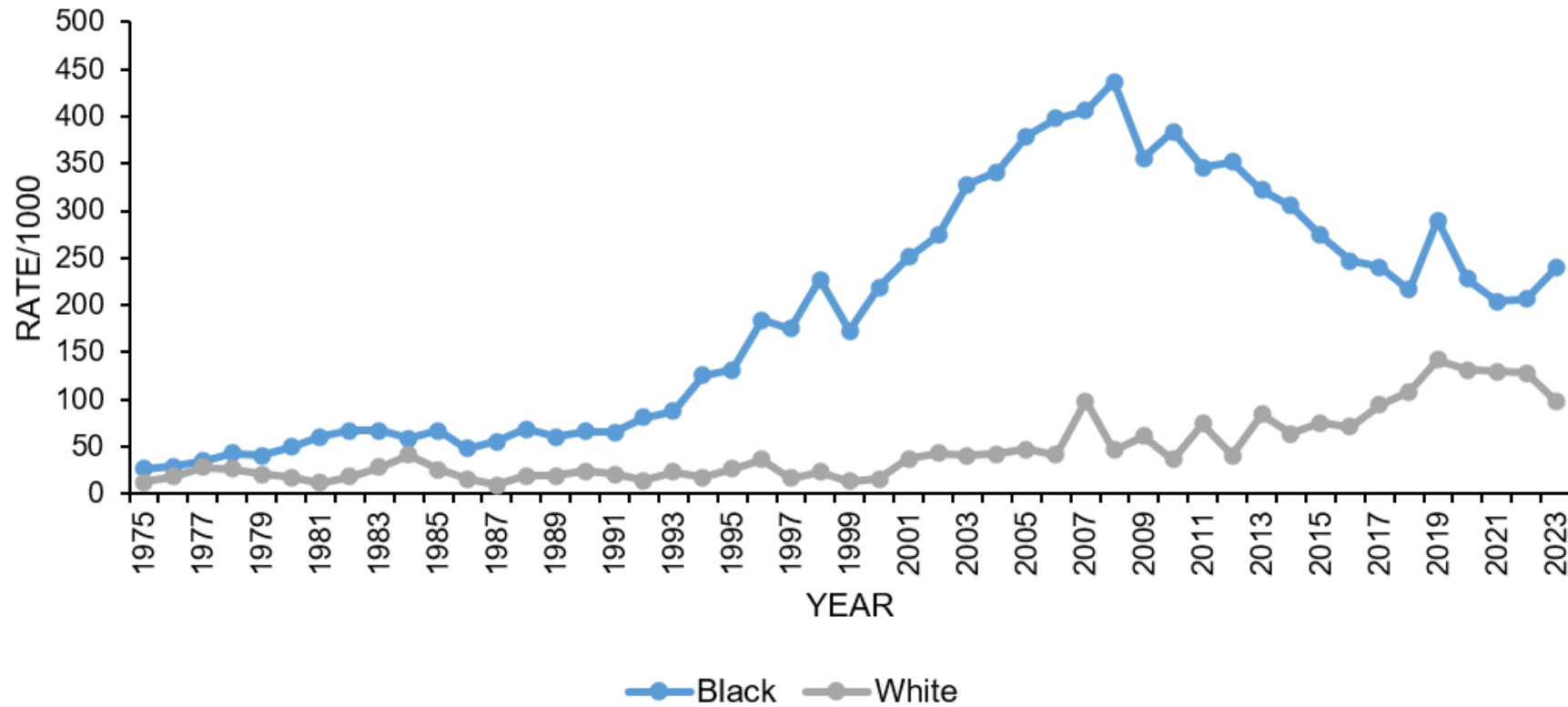


Figure 3. Active PTB rates in black and white miners at autopsy (1975-2023)



Figure 4. First picture is of a lung affected by TB showing caseous necrosis and the second picture depicts TB involving the pericardium



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The relationship between silica exposure, silicosis, and active PTB is well described in science.^{2,3,4}

- ▶ The 2001 Occupational Health Practice in the South African mining industry handbook, by Guild et al.² Recommended :
 - ▶ TB preventative therapy,
 - ▶ Increased active case finding,
 - ▶ HIV prevention,
 - ▶ Reduced use of the hostel system,
 - ▶ Better dust control
- ▶ The handbook also recommends better dust control and prevention of TB and HIV infection to reduce silicosis in mining.²



SILICOSIS

- ▶ Silicosis is an incurable occupational lung disease caused by respirable crystalline silica exposure.
- ▶ It is incurable and is the focus of global reduction efforts.²
- ▶ Silicosis was the second most diagnosed disease at autopsy in miners in at the NIOH.
- ▶ The majority of silicosis cases were seen in gold miners, followed by platinum, asbestos and coal miners.

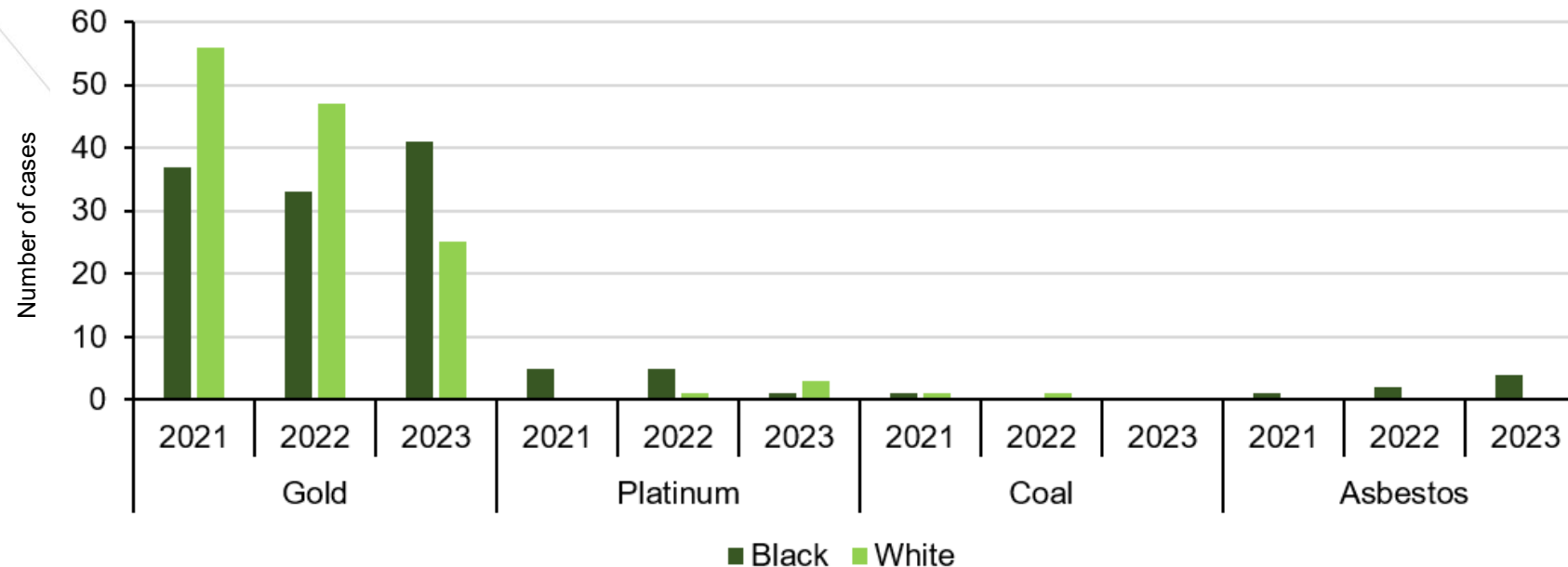


Figure 5. Number of cases of silicosis by commodity and population group (2021 - 2023)

SILICOSIS

- ▶ In Black gold miners, a reduction was seen in the late 90s, then steady growth in rates of silicosis in Black miners before decreasing slightly.
- ▶ Fairly stable rates are seen in white miners and remain high in black gold miners and ex-miners.

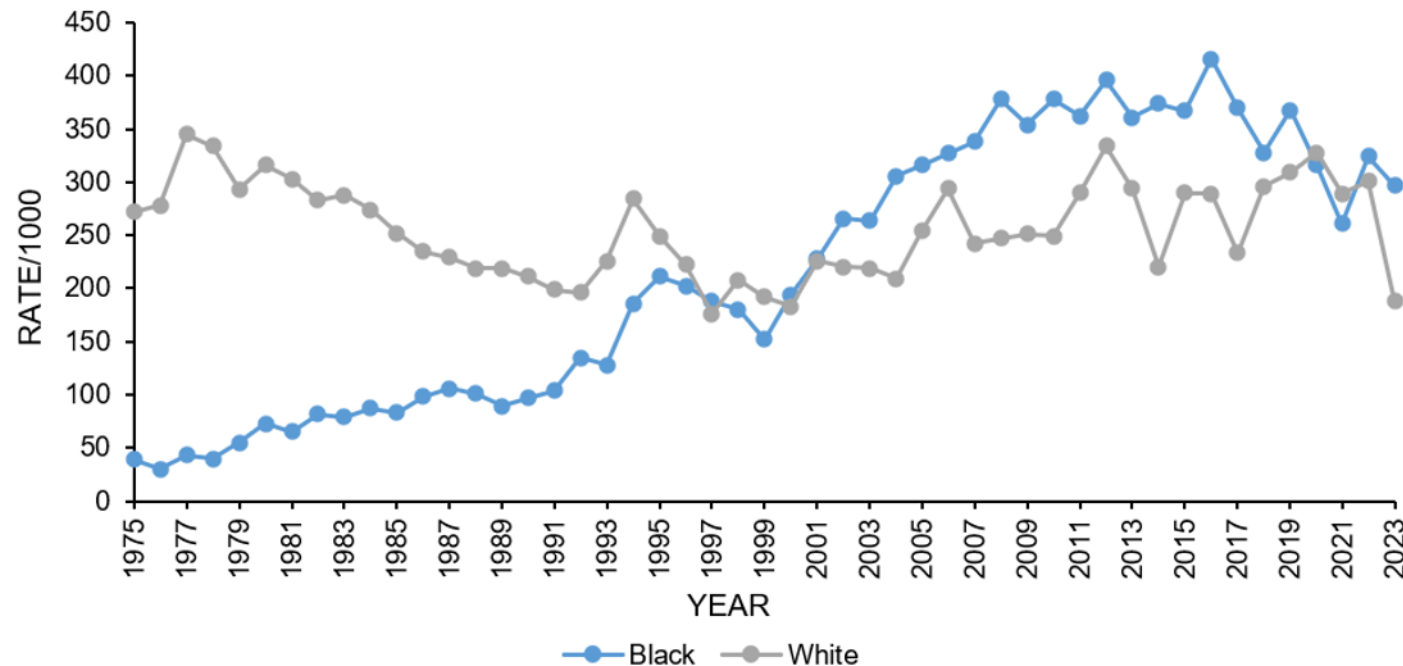


Figure 6. Silicosis in black and white gold miners at autopsy (1975-2023)



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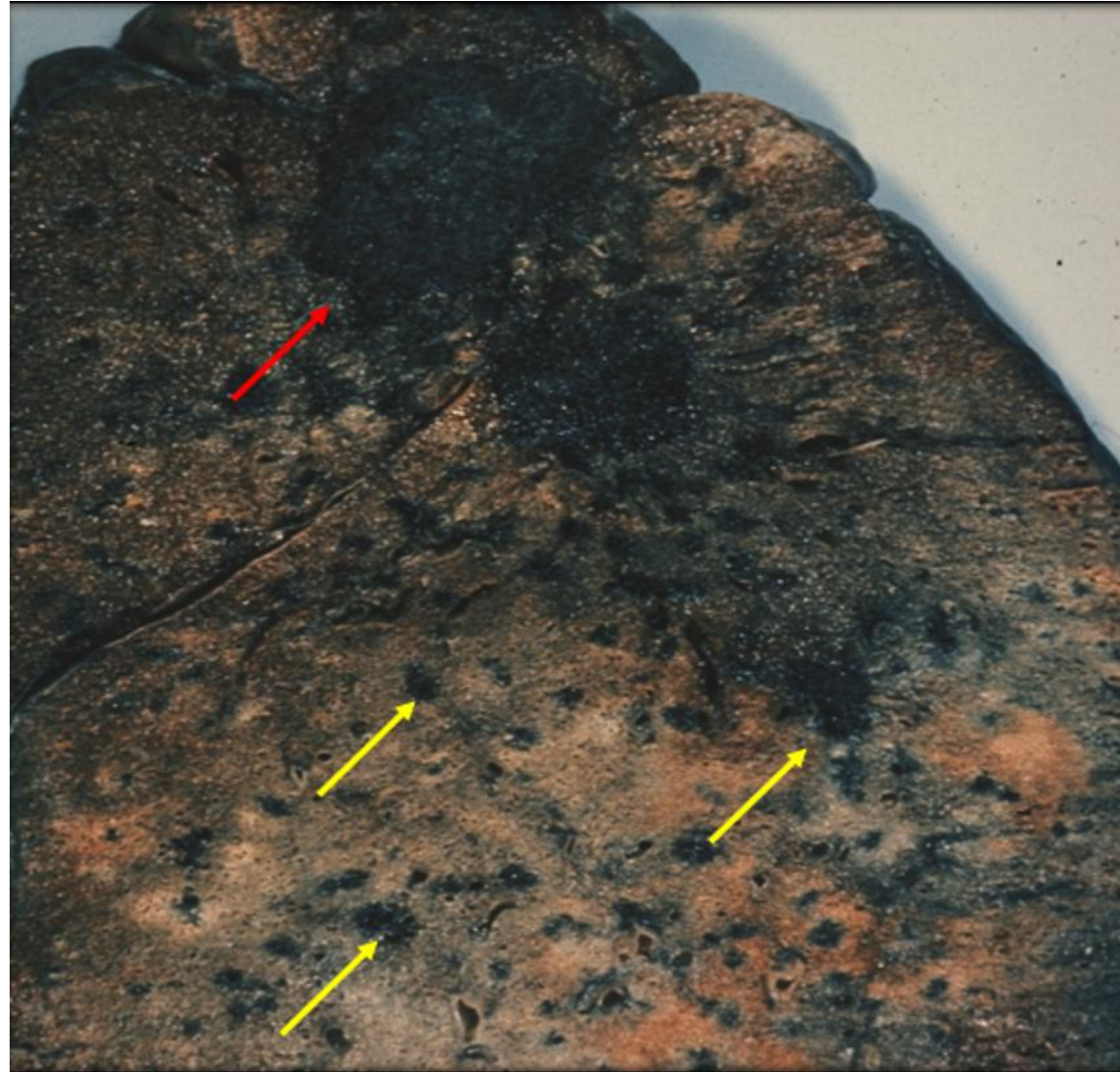


Figure 7. A Lung with PMF (Red arrow) and silicotic islets extending to lower lobe (yellow arrows)

EMPHYSEMA

- ▶ Emphysema is an irreversible chronic lung disease where the tiny air sacs (alveoli) in the lungs are damaged. Making it difficult to breathe and leading to progressive shortness of breath.
- ▶ It is most often associated with smoking,⁴ (although the autopsy database contains limited data on smoking history)
- ▶ Long-term exposure to dust and fumes, pollution can also contribute.
- ▶ Globally 6.5% of COPD deaths are attributed to occupational exposures and 32.6% to active smoking the remainder are attributed to ambient air pollution.
- ▶ **2023 Pathaut – 493/1000 autopsies**



Figure 8. Severe panlobular emphysema. The spaces are of variable size and tend to affect the whole lung

MESOTHELIOMA

- ▶ Mesothelioma is a rare but aggressive cancer that develops in the thin protective lining (mesothelium) surrounding the lungs and is strongly linked to asbestos exposure.
- ▶ There were 18 cases (33/1000) in 2021, 26 (63/1000) in 2022 and 36 cases (80/1000) in 2023.
- ▶ Predominantly seen in miners aged 50 years and above.

Table 3. Percentage of mesothelioma cases by asbestos commodity (2021 - 2023)

	2021	2022	2023
Asbestos mining history	77.8%	73.1%	66.7%
Longest service in asbestos mining	44.4%	46.2%	52.8%
Mixed exposures that included asbestos	38.9%	26.9%	13.9%

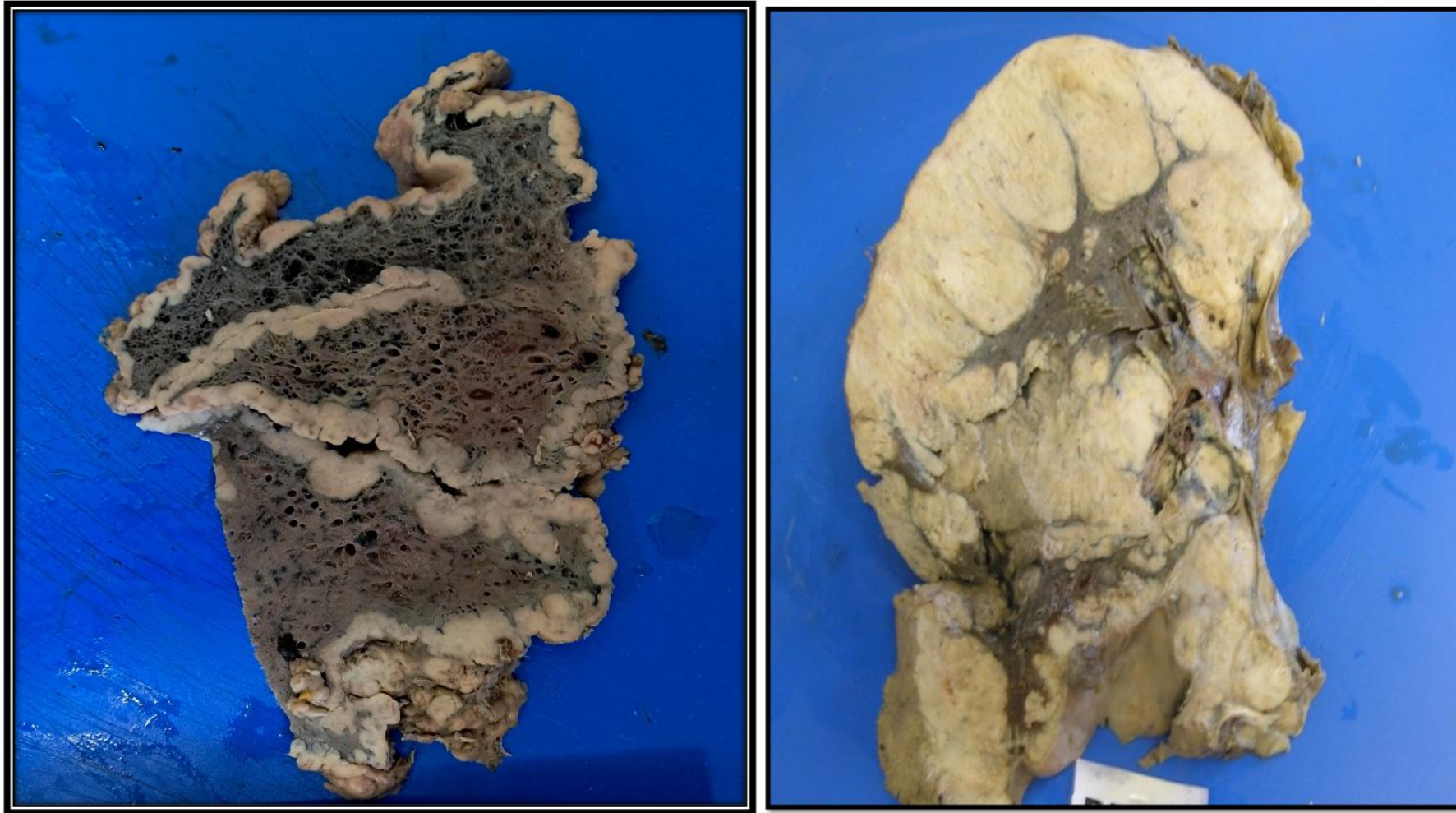


Figure 9. A lung with mesothelioma involving both the pleura and parenchyma



Table 4. Province of death for mesothelioma cases (2021 - 2023)

	Northern Cape N (n)	Gauteng N (n)	North West N (n)	Limpopo N (n)	Western cape N (n)	Free State N (n)
2021	16 (0)	-	2 (1)	-	-	-
2022	24 (0)	-	-	-	-	1 (0)
2023	30 (0)	2(1)	2(2)	1(1)	1 (0)	-
Total	70	2	4	1	1	1

N refers to number of cases with mesothelioma

n refers to number of cases by death certificate

Needs:

- Better awareness of autopsy service and info against stigma.
- Better access for pathology services
- Expand service to more mines and those environmentally exposed

ASBESTOSIS

- ▶ Asbestosis is an interstitial lung disease associated with asbestos exposure.
- ▶ South Africa stopped mining this commodity in 2002.^{1,3}
- ▶ There were 46 cases (84/1000) in 2021, 32 (78/1000) in 2022 and 46 cases (102/1 000) in 2023.
- ▶ Asbestosis rates remained constant from 29/1000 in 1975 to 29/1000 in 2005, following which the rates increased to 50/1000 in 2015 and doubled to 102/1000 in 2023.

Table 5. Percentage of cases by asbestos exposure (2021 - 2023)

	2021	2022	2023
Cases (percentage)	46/546 (8.4%)	32/410 (7.8%)	46/450 (10.2%)
Asbestos mining history	84.8%	78.1%	84.8%
Environmental exposure	1.0%	0.0%	0.0%



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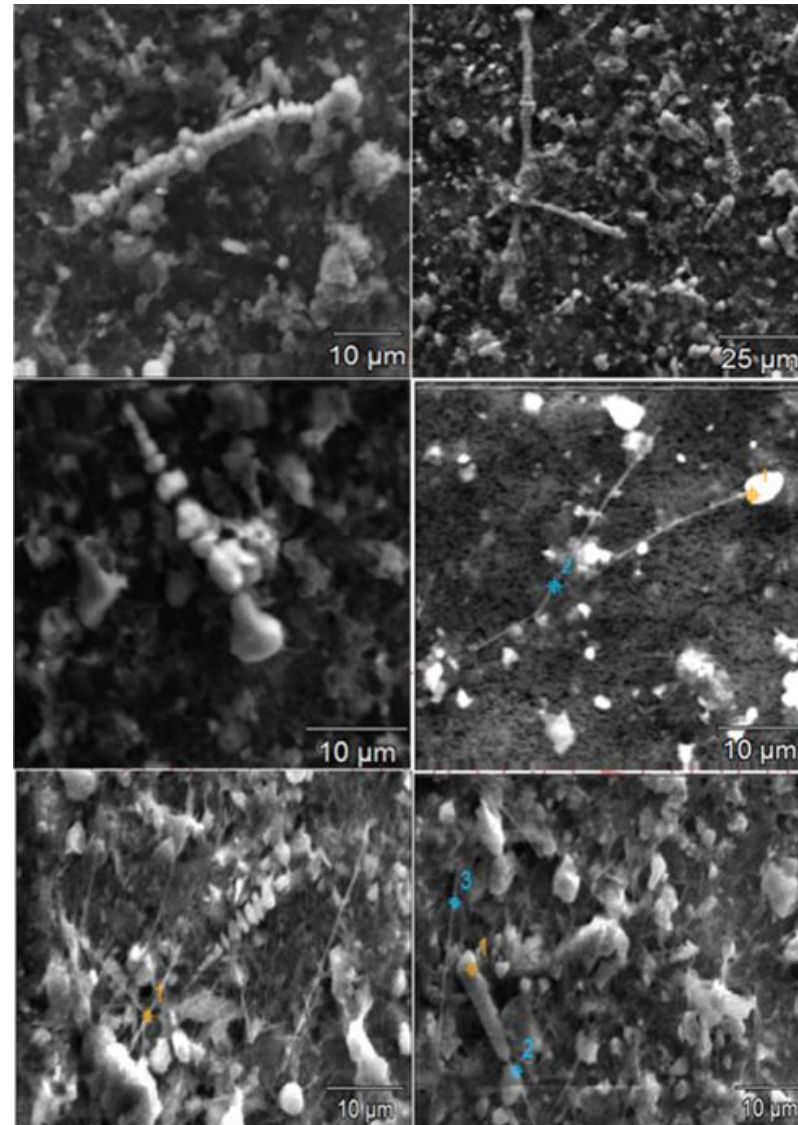


Figure 10. SEM image depicting asbestos fibres and asbestos bodies in a digested lung sample

Lung Cancer

- ▶ There is limited information on smoking history in this database; thus, attribution of occupational exposures as an aetiology is complicated.
- ▶ Mining has well-described exposures to carcinogenic substances such as silica, asbestos, radon and diesel exhaust fumes, which may act alone or synergistically with smoking to cause lung cancer.¹³

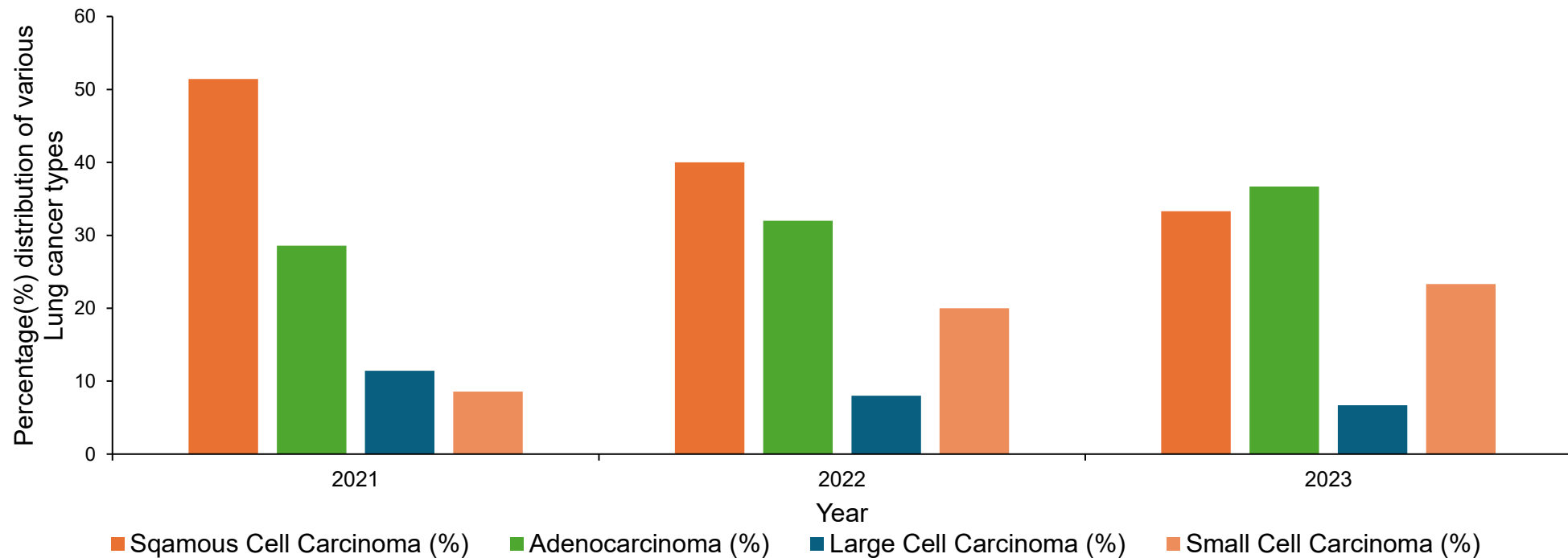


Figure 11. Percentage of various lung cancer types (2021 - 2023)



Figure 12. An image showing carcinoma of the lung



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DUST-RELATED MASSIVE FIBROSIS

- ▶ Massive fibrosis is a severe, progressive scarring of lung tissue caused by prolonged dust exposure, leading to significant respiratory impairment and increased susceptibility to infections.
- ▶ Dust-related massive fibrosis was 1/1000 in 1975 to 10/1000 in 2005. The rates then showed a faster increase to 19/1000 in 2018.
- ▶ The pathological classification of massive fibrosis changed in 2019 from lung fibrosis measuring 2 cm and more to lung fibrosis measuring 1 cm and more. This was changed to align the NIOH diagnosis with the International Labour Organisation (ILO) definition.¹⁴
- ▶ The impact of the wider definition of massive fibrosis increased the rate to 41/1000 in 2019, after which the rates remained high.

DUST-RELATED MASSIVE FIBROSIS

The rate of massive fibrosis in 2023 (16/1 000) was sharp decline from that of 2022 (29/1 000) and 2021 (37/1000). In 2021, 80% (n=16) of the cases were gold miners, twelve of the cases (60%) were in black miners, and eight (40%) were in white miners.

Table 4. Number of cases of massive fibrosis by commodity and population group (2021 - 2023)

Year	2021	2022	2023
cases	20/546 (3.7%)	12/410 (2.9%)	7/450 (1.6%)
Miners			
Black	60%	50%	86%
White	40%	50%	14%
Commodity			
	80% Gold mining	92% Gold mining	All from gold mining
	5% Asbestos	8% Copper mining	
	5% Coal		
	5% Platinum		
	5% Unknown		

Coal Workers Pneumoconiosis and mixed dust pneumoconiosis

- ▶ There was one case of coal workers' pneumoconiosis in cases examined in 2021 and 2023, and no cases were seen in 2022.
 - ▶ This reflects the low numbers of cases received from the coal mining industry.
- ▶ In 2021, there were two (0.4%) cases of mixed dust pneumoconiosis in cases examined.
 - ▶ The two cases were from the platinum and manganese mining industries.
- ▶ In 2022, there were two (0.5%) cases of mixed dust pneumoconiosis in cases examined.
 - ▶ The two cases were from the gold and asbestos mining industries.
- ▶ In 2023, there was one cases of mixed dust pneumoconiosis in cases examined in 2023.
 - ▶ The single case is from the gold mining industry.

CONCLUSIONS

Miners previously exposed to asbestos continue to develop occupational respiratory diseases due to the long latency of asbestos-related conditions.

While rates of active pulmonary tuberculosis (PTB) and silicosis among gold miners have declined, they remain higher than 1995 levels (93/1000 for PTB, 182/1000 for silicosis).

Fewer miners and ex-miners are undergoing autopsy, potentially limiting disease confirmation and access to compensation.

RECOMMENDATIONS

- ▶ Outreach campaigns
- ▶ Adhere to policies to control dust in the mining industry
- ▶ Continued surveillance of occupational respiratory diseases

REFERENCES

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Full data/information can be accessed on the Pathology division surveillance reports:
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