

# Occupational lung diseases in South African miners at autopsy: 2020 surveillance report

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## BACKGROUND

Mining has been recognised as a determinant of respiratory diseases for hundreds of years.<sup>1</sup> The National Institute for Occupational Health (NIOH) undertakes autopsy examinations on the cardio-respiratory organs of deceased miners and ex-miners who worked in controlled mines and works (diggings, quarries, and brickworks) for compensation purposes, in terms of the Occupational Diseases in Mines and Works Act (ODMWA).<sup>2</sup> Autopsies are performed at no charge to miners, with consent from the next of kin, and regardless of the clinical cause of death.<sup>3</sup> For persons dying distant from Johannesburg, the organs are removed locally, preserved in formalin, and sent to the NIOH for examination.<sup>4</sup> Demographic information, clinical cause of death, and occupational histories are submitted to the NIOH, together with the organs.<sup>4,5</sup> Clerical staff follow up with families, employers, and the Medical Bureau for Occupational Diseases (MBOD) to obtain missing information. Since 1975, all information, and detailed autopsy findings, have been recorded on an electronic database called the Pathology Automation (PATHAUT) system.<sup>5</sup> The PATHAUT database, which comprised 114 793 records by 2020, is used for surveillance and research. Detailed annual surveillance reports are available on the NIOH website.<sup>6</sup>

A detailed report of each case is sent to the (MBOD)<sup>3,5</sup> for certification of disease by a panel of doctors. Cases with compensable diseases are submitted to the Compensation Commissioner for Occupational Diseases office, which manages payments to the deceased's family.<sup>3</sup>

## ABSTRACT

The Pathology Division at the National Institute for Occupational Health (NIOH) provides autopsy services for deceased workers who worked in controlled mines or works under the provisions of the South African Occupational Diseases in Mines and Works Act, 1973 (Act No. 78 of 1973). This report describes the ages, commodities, employment durations, and occupational cardio-respiratory diseases in miners whose organs were submitted for autopsies in 2019 and 2020. Data were exported from the PATHAUT database into STATA for analysis. Differences in the proportions of disease (expressed per 1 000) were calculated using the Pearson's chi-square test; significance was set at  $p \leq 0.05$ . There were 759 and 557 records of deceased miners and ex-miners in 2019 and 2020, respectively. Pulmonary tuberculosis decreased from 192/1 000 in 2019 to 153/1 000 autopsies in 2020, and silicosis decreased from 246/1 000 to 223/1 000. However, neither decrease was significant. There was a significant increase in the rate of asbestosis from 50/1 000 in 2019 to 79/1 000 in 2020. Pulmonary tuberculosis (TB), emphysema, and silicosis were the most frequent diseases, with high rates. There was a non-significant decrease in occupational respiratory disease rates in 2020 from 2019, but these remain higher than the rates seen in the early 1990s. The NIOH continues to conduct autopsy surveillance on miners to support compensation for families, and the development of policy and intervention programmes in the mining industry.

In this report, we present an overview of findings published in the 2020 annual pathology surveillance report, the first to be written during the COVID era. The findings for 2019 are also described to highlight changes in the rates of occupational lung diseases in 2020.

## METHODS

All records for 2019 and 2020 were exported from the PATHAUT database into SAS Enterprise Guide version 7.1 for data management, and then into STATA (version 16) for analysis. The rates of disease were expressed as proportions per 1 000 autopsies per year. Basic descriptive analyses were performed, summarising continuous data variables as means and standard deviations, and categorical data variables as numbers and percentages. Pearson's chi-square analysis was conducted to describe the exposure and disease findings, and to compare findings for 2019 and 2020.

Ethical clearance to analyse the data was provided by the University of the Witwatersrand (certificate number: M220564). Permission to access the PATHAUT data was obtained from the Academic Affairs Research and Quality Assurance Department of the National Health Laboratory Service.

## RESULTS AND DISCUSSION

### Demographic characteristics

There were 557 autopsy examinations conducted during 2020, compared to 759 in 2019: a 26% decrease. Demographic characteristics from 2019 and 2020 are presented in Table 1.

The distribution of the demographic data from 2019 and 2020 was similar. There were no significant differences in proportions of miners by sex, race, commodity, or employment status between the two years. Although the overall mean age at autopsy was two years greater in 2020, the difference was not significant.

**Table 1. Demographic characteristics of miners whose organs were examined at the NIOH in 2019 and 2020**

Characteristic	2019 n = 759		2020 n = 557	
	Mean	SD	Mean	SD
Age (years)				
All	61.4	14.0	62.4	14.3
Black	54.5	13.6	54.9	13.9
White	68.2	11.7	69.9	9.8
Duration of employment (years)				
All	20.5	10.8	19.1	11.1
Black	15.0	10.0	15.3	10.4
White	22.9	10.3	23.7	9.8
	<b>n</b>	<b>%</b>	<b>n</b>	<b>%</b>
Sex				
Female	26	3.4	29	5.2
Male	731	96.3	528	94.8
Unknown	2	0.3	-	-
Race				
Black	445	58.6	304	54.6
White	307	40.5	251	45.1
Other	7	0.9	2	0.4
Province				
North West	241	31.8	155	27.8
Gauteng	195	25.7	153	27.5
Free State	145	19.1	94	16.9
Northern Cape	94	12.4	93	16.7
Mpumalanga	36	4.7	32	5.8
Eastern Cape	6	0.8	7	1.3
KwaZulu-Natal	8	1.1	6	1.1
Limpopo	3	0.4	10	1.8
Western Cape	3	0.4	6	1.1
Other Countries	28	3.7	1	0.2
Commodity*				
Gold	464	61.1	335	60.1
Platinum	127	16.7	82	14.7
Asbestos	59	7.8	69	12.4
Coal	34	4.5	27	4.9
Other†	63	8.3	37	6.6
Unknown or not stated	12	1.6	7	1.3
Employment status				
Current	263	34.7	187	33.6
Ex-miner	481	63.4	348	62.5
Unknown or environmental	15	2.0	22	4.0

\*Workers often have mixed service and are classified according to the commodity in which they had the longest service

†Chrome, diamond, environmental asbestos, Eskom, iron, lead, lime, silica, works, quarry, steel, SA railways, cement

## Pathological findings

The overall rates of occupational lung diseases diagnosed at autopsy in 2019 and 2020 are shown in Figure 1. Pulmonary tuberculosis (PTB), emphysema, and silicosis were the most frequently occurring diseases. No cases of coal workers' pneumoconiosis or mixed dust pneumoconiosis were diagnosed in 2020 and 2019.

The only statistically significant difference in rates in 2019 and 2020 was for asbestosis ( $p = 0.0319$ ). The differences in rates of other lung diseases between the two years were not statistically significant, with  $p$  values that ranged from 0.0611 to 0.7539.

## Active pulmonary tuberculosis

Active pulmonary TB (PTB) was diagnosed in 15.3% ( $n = 85$ ) of all autopsies in 2020. Most cases were from the gold ( $n = 57, 67.1%$ ) and platinum ( $n = 14, 14.7%$ ) mining industries. The majority of miners with PTB were black ( $n = 55, 64.7%$ ). The overall rate of PTB in all autopsied miners decreased from 192/1 000 in 2019 to 153/1 000 in 2020 (Figure 1); however, this was not statistically significant ( $p = 0.0611$ ). Figure 2 shows PTB in black miners over time. Pulmonary tuberculosis at autopsy has declined since peaking at 368/1 000 in 2007, to 181/1000 in 2020.

Although PTB rates were still high compared to the 1980s and early 1990s, there has been an annual decline since 2007. The reasons for this are multifactorial and include a decline in silica dust exposure, improved living conditions, and the roll-out of antiretroviral treatment.<sup>6</sup>

## Silicosis

In 2020, silicotic nodules were found in the lungs of 124 miners. Most miners ( $n = 108, 87.1%$ ) had their predominant exposure in the gold mining industry. In 2019, 187 miners had silicotic nodules in the lungs, with the majority ( $n = 108, 57.8%$ ) also having had exposure in the gold mining industry. The overall rate of silicosis decreased from 246/1 000 in 2019 to 223/1 000 in 2020 (Figure 1), but this difference was not statistically significant ( $p = 0.3162$ ).

The rates of silicosis in black gold miners from 1975–2020 are presented in Figure 3. The rate decreased from 369/1 000 in 2019 to 316/1000 in 2020.

## Massive fibrosis

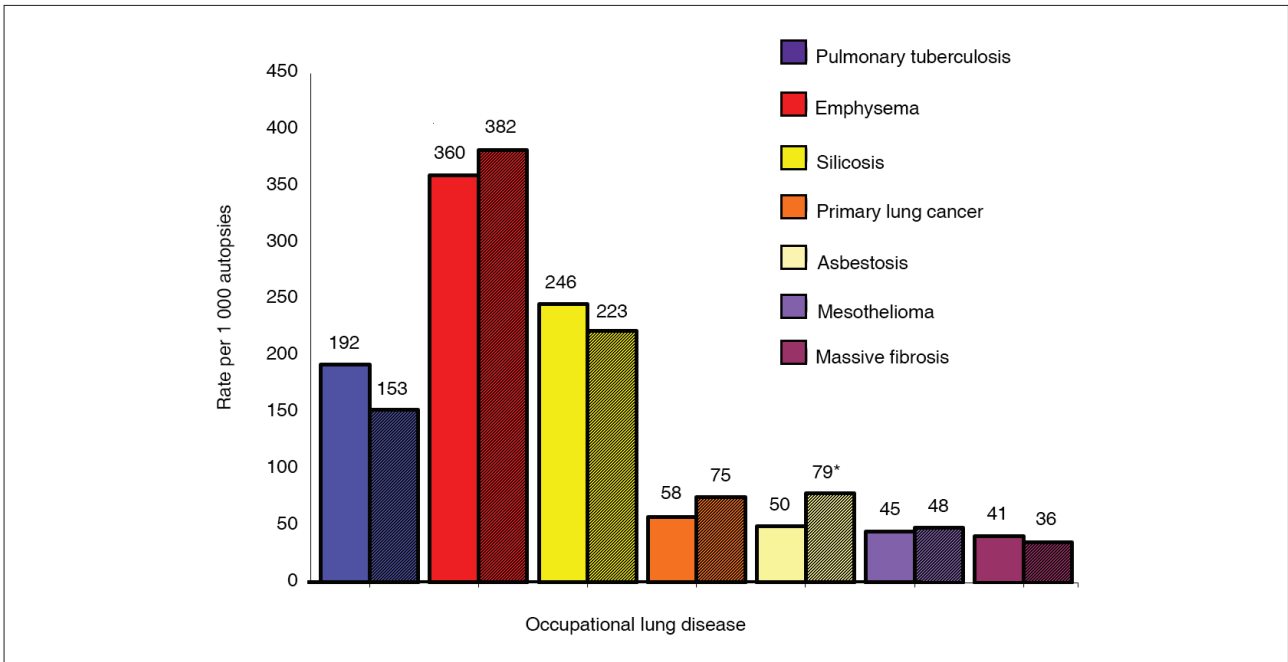
The rate of massive fibrosis in 2020 (36/1 000) was similar to that in 2019 (41/1 000) ( $p = 0.6466$ ). In 2020, of the 20 (3.6%) miners with massive fibrosis, 18 (90.0%) were gold miners. In 2019, 31 (4.1%) of all autopsied miners had massive fibrosis, of which 27 (87.1%) were from the gold mining industry.

## Emphysema

Emphysema remains a commonly diagnosed respiratory disease at autopsy (Figure 1). In 2020, emphysema was diagnosed in 213 miners, the extent of which was mild in 82.2% ( $n = 175$ ), moderate in 15.5% ( $n = 35$ ), and marked in 1.4% ( $n = 3$ ). In 2020, the rate of emphysema increased to 382/1 000 compared to 360/1 000 in 2019, but the difference was not statistically significant ( $p = 0.3988$ ). The high rates of emphysema have been attributed to the continued use of tobacco products and exposure of miners to harmful occupational dust.<sup>7</sup>

## Asbestos-related diseases

There were 44 cases of asbestosis in 2020. Of these, 36.4% ( $n = 16$ ) had slight, 43.2% ( $n = 19$ ) had moderate, and 20.5% ( $n = 9$ ) had marked fibrosis. Thirty-six (81.8%) of those with asbestosis had worked in the asbestos mining industry, and three (7.0%) had



Note: plain bars show data for 2019; scored bars show data for 2020  
 \*Statistically significantly different at  $p \leq 0.05$

Figure 1. Overall disease rates for 2019 and 2020

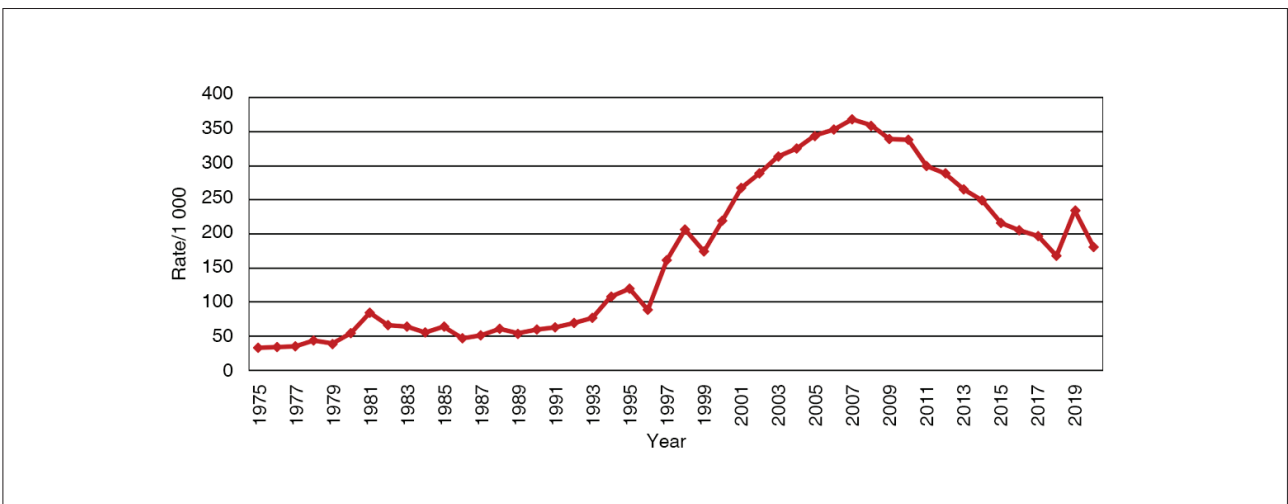


Figure 2. Active PTB rates in black miners at autopsy (1975–2020)

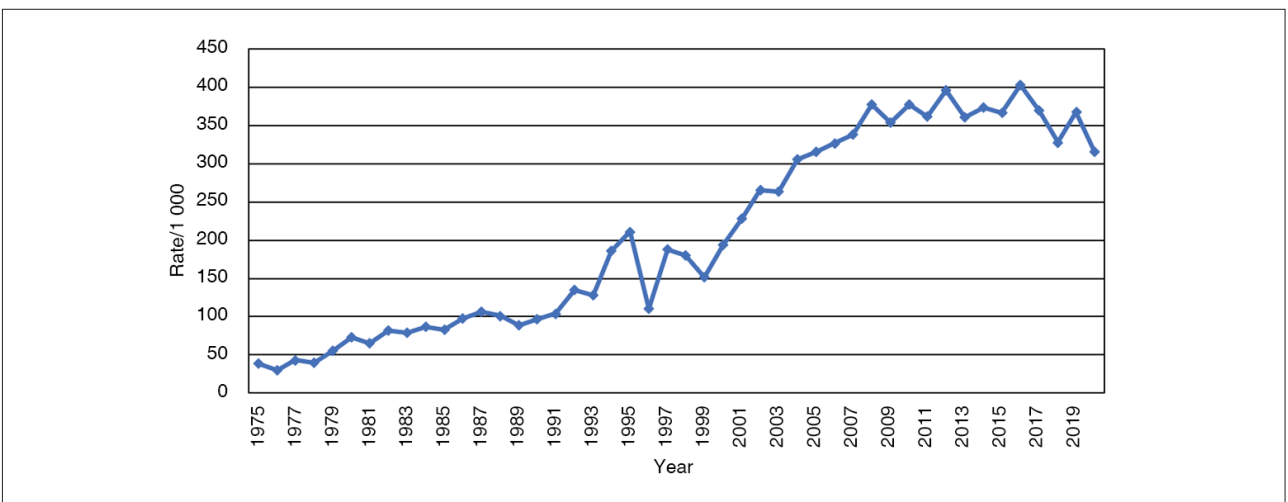


Figure 3. Silicosis in black gold miners at autopsy (1975–2020)

environmental asbestos exposure. There were 27 cases of mesothelioma. Nineteen (70.4%) of those with mesothelioma had worked in asbestos mines, two (7.4%) in gold mines, and two (7.4%) in formal works; three (11.1%) had environmental exposures, and exposure was unknown for the remaining individual (3.7%). The rates of asbestosis increased significantly from 50/1 000 in 2019 to 79/1 000 in 2020 ( $p = 0.0319$ ). The proportions of workers with mesothelioma were similar in 2019 (45/1 000) and 2020 (48/1 000) ( $p = 0.7539$ ).

### Primary lung cancer

In 2020, primary lung cancer was diagnosed in 42 miners. Seventeen (40.5%) were in black and 25 (59.5%) were in white miners. Most of the cancers were adenocarcinoma ( $n = 20$ , 47.6%), followed by squamous cell carcinoma ( $n = 14$ , 33.3%), small cell carcinoma ( $n = 5$ , 11.9%), and large cell carcinoma ( $n = 3$ , 7.2%). Most of the miners with lung cancer came from the gold mining industry ( $n = 28$ , 66.7%), although the highest rate was seen in the asbestos miners (116/1 000). The rates of lung cancer were similar in 2019 and 2020 (58/1 000 and 75/1 000, respectively) ( $p = 0.2061$ ). Adenocarcinoma was the most common subtype in both years.

### Autopsy findings in women

The organs of 26 and 29 women were submitted for autopsy in 2019 and 2020, respectively. In 2020, 86.2% ( $n = 25$ ) of the women had a history of occupational exposure, with most having worked in the asbestos mining industry ( $n = 16$ , 55.2%), followed by 13.8% ( $n = 4$ ) in the gold mining industry, and 17.2% ( $n = 5$ ) in other commodities; 13.8% ( $n = 4$ ) had environmental asbestos exposure. The women who had autopsies in 2019 had similar work exposures to those in 2020.

Fifteen women (51.7%) had diseases related to asbestos exposure in 2020, and five in 2019. Seven had asbestosis (24.1%) compared to three (11.5%) in 2019, while eight had mesothelioma (27.6%) in 2020 compared to two (7.7%) in 2019. Neither of the differences in proportions between the two years were significantly different ( $p = 0.2261$  and  $p = 0.0561$ , respectively). Pulmonary TB was diagnosed in 10.0% of women in 2020 and 19.2% in 2019. Asbestosis, mesothelioma, and PTB were the most common occupational diseases in women in both 2019 and 2020.

### Clinical cause of death

The clinical cause of death is not determined by pathologists at the NIOH. It is stated in the accompanying documents submitted with the cardio-respiratory organs. Respiratory system diseases were the most common specified cause of death in both 2019 ( $n = 119$ , 15.7%) and 2020 ( $n = 84$ , 15%). Miscellaneous causes (natural causes, not specified) accounted for the largest proportion of deaths: 46.9% ( $n = 356$ ) in 2019 and a significantly higher proportion ( $n = 334$ , 60.0%) in 2020 ( $p < 0.0001$ ). The increase in the proportion of miners recorded to have miscellaneous causes of death in 2020 may have been driven by a drop in the proportion of cases where the cause of death was not stated, from 20.3% ( $n = 154$ ) in 2019 to 8.1% ( $n = 45$ ) in 2020.

### Clinico-pathological findings in miners with COVID

In 2020, clinically, six miners were stated to have had COVID-19-related deaths; one was recorded as a possible COVID-19-related death. All were male, with ages ranging from 41 to 85 years. Five of the seven men died during the first wave of the COVID-19 pandemic (7 June 2020 to 22 August 2020), and two died in the second wave

(15 November 2020 to 6 February 2021). Five were current miners, and two were ex-miners. The men had worked in gold ( $n = 4$ ), platinum ( $n = 2$ ), and manganese ( $n = 1$ ) mines.

The pathological findings in the seven cases were diffuse alveolar damage, pneumonia, coronary artery disease, myocarditis, and pulmonary thromboembolism. There were no cases of PTB, although there were two cases of silicosis.

### CONCLUSION

There has been a steady annual decrease in the number of organs submitted to the NIOH since 1995.<sup>8</sup> In 2020, there was a 26% decrease in the number of autopsies received compared to 2019. The decrease in cases could be due to the contracting employment in the country's mining sector, from approximately 344 000 mineworkers in 1994 to 94 399 in 2020.<sup>9</sup> Furthermore, the COVID-19 lockdowns may have caused logistical challenges, such as lack of access to facilities where autopsies are performed, and transportation of organs to the NIOH. This was due to the fact that most non-essential services were not operational, and mines, and provincial and national borders, were closed during the lockdowns. Hence, many families could have missed the opportunity to have the organs of their deceased members submitted to the NIOH and to receive compensation for any occupational lung disease diagnosed at autopsy.

Except for asbestosis, for which an increase was observed, there were no significant differences in the rates of occupational lung diseases in 2020 and 2019. This demonstrates that, although asbestos mining has ceased, asbestos-related diseases are prevalent.

In the cases with COVID-19 listed as a cause of death, diffuse alveolar damage and pneumonia were noted at autopsy, similar to findings in an international systematic review conducted by Deshmukh et al.<sup>10</sup>

High rates of preventable occupational diseases in South African miners are still a subject of concern. The 2020 report shows that the rates of PTB and silicosis in black miners remain high. This is despite progress that has been made in improving working conditions in South African mines.<sup>11</sup> The NIOH continues to conduct autopsies for the diagnosis of occupational respiratory diseases in miners to support compensation for families. This information that is generated is used for disease surveillance, and the development of occupational health policy and intervention programmes in the mining industry.

*Note: The annual Pathology Division reports based on the PATHAUT data from 1975 to 2020 are available on the NIOH website: [www.nioh.ac.za/pathology-division-surveillance-reports/](http://www.nioh.ac.za/pathology-division-surveillance-reports/)*

### KEY MESSAGES

1. The continued decline in numbers of organs submitted to the NIOH for autopsy is of concern, with a 26% decrease from 2019 to 2020.
2. The rates of autopsy-diagnosed silicosis and PTB in South African miners remain high.
3. With the exception of asbestosis, the proportions of miners with occupational diseases were similar in 2019 and 2020.

### DECLARATION

The authors declare that this is their own work; all the sources used in this report have been duly acknowledged, and there are no conflicts of interest.

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**AUTHOR CONTRIBUTIONS**

Conception and design of the study: JM, DGL, LNM, KSW

Data acquisition: LNM, ZBN, DF

Data analysis: LNM, KSW

Interpretation of the data: LNM, ZBN, KSW, JM, DF, DGL

Drafting of the paper: LNM

Critical revision of the paper: ZBN, KSW, DF, DGL, JM

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