Marikana autopsies highlight occupational diseases amongst platinum mine workers

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ABSTRACT
Background: In August 2012, 34 platinum mine workers were shot and killed by police at Marikana. After forensic autopsies, the cardio-respiratory organs of the deceased men were sent to the National Institute for Occupational Health for examination for compensable disease in terms of the Occupational Diseases in Mines and Works Act (Act 78 of 1973).

Methods: A review of the autopsy records provides some insight into the health and social issues faced by mine workers employed on a South African platinum mine.

Results: Platinum mine workers experience high rates of silicosis and pulmonary tuberculosis, some of which can be attributed to cross recruitment, migrancy and the contract labour system. These problems are exacerbated by poor living conditions.

Conclusion: Many factors add to the burden of ill health of platinum and other mine workers. This small series of autopsies highlights some of the social and economic issues which persist, despite decades of research and resulting recommendations, primarily in gold mine workers.

Keywords: silicosis, tuberculosis, cross-recruitment, migrant workers, contract workers, compensation

INTRODUCTION
Following failed wage negotiations and unrest in the area, approximately 3 000 striking platinum mine workers were gathered on a hill close to the town of Marikana, near Rustenburg, in the North West province of South Africa on 16 August 2012. The police dispersed the crowd on the hill and, in the course of this action, injured 78 mine workers and shot and killed 34 others. This incident and the events leading up to it are currently being investigated by a Commission of Inquiry chaired by Judge Ian Gordon Farlam.1

In terms of the provisions of the Occupational Diseases in Mines and Works Act of 1973,2 the National Institute for Occupational Health (NIOH) examines the cardio-respiratory organs of deceased mine workers submitted to the Medical Bureau for Occupational Diseases (MBOD), for the presence of compensable disease. Data obtained from the examination of these organs are entered into a database known as PATHAUT. The database was established in 19753 and now contains demographic and pathological (macro- and microscopic) information on more than 100 000 deceased mine workers who worked in various South African mines and works. These data are in the public domain in the form of a series of annual reports4 and have been used in the publication of more than 100 scientific papers and technical reports.

Following forensic autopsies, which are conducted on all individuals who die from unnatural (external) causes, the organs of the 34 deceased platinum mine workers were submitted for examination at the NIOH. Although these mine workers are not representative of all platinum mine workers in South Africa who die from external causes, they are a homogeneous group in that they were all working for the same mining company and they all died on the same day.

The purpose of this paper is to describe the respiratory autopsy findings in the mine workers who died at Marikana on 16 August 2012, in order to provide some insight into the health of mine workers currently employed on the South African platinum mines, some associated social issues, and the importance of the autopsy service offered in terms of the Occupational Diseases in Mines and Works Act.2

METHODS
Autopsies are conducted at the NIOH by skilled pathologists according to standardised methods. Silicosis in the lungs (pulmonary silicosis) is diagnosed when palpable nodules, evident on macroscopic examination of the lung parenchyma, are confirmed histologically, to display whorled concentric fibrosis. The severity of disease is determined by the number of silicotic nodules on macroscopic examination. If the
nodules in the lungs measure more than 1 cm in diameter, progressive massive fibrosis (PMF) is diagnosed. Fibrotic nodules with the same histological characteristics as silicotic nodules in the lung parenchyma may also be evident in the lymph glands, and may be a sensitive indicator of the potential to develop silicosis. Active pulmonary tuberculosis is diagnosed when epithelioid granulomas, associated with caseous necrosis, are present. Inactive tuberculosis is characterised by necrosis, surrounded by fibrous tissue; there are no granulomas.

If a currently or previously employed mine worker is diagnosed with a compensable disease in life, his employment history and medical records are reviewed by a panel of experts at the MBOD and a decision is reached with regard to his eligibility for compensation, based on a number of pre-determined criteria. The presence of disease, as well as the severity, is assessed. If the mine worker is certified as having a compensable disease, the necessary documents are sent to the Compensation Commissioner for Occupational Diseases where the employment record and other documents are checked and the beneficiaries are authenticated. The compensation amount is then calculated. Depending on the extent of the disease, the compensation is categorised as first or second degree. The same procedure applies for disease diagnosed at autopsy.

The autopsy findings on the 34 mine workers recorded in the PATHAUT database were reviewed, together with records from the MBOD which were used to obtain employment histories and details with regard to certification of compensable disease.

The names, dates of birth and places of burial of the deceased were verified using information in Professor Peter Alexander and colleagues’ book on the events that culminated in the shootings at Marikana in August 2012. Approval for the study was obtained from the University of the Witwatersrand Human Research Ethics Committee (clearance certificate no. M140275).

RESULTS

Demographic characteristics
All the deceased mine workers were black men and had a median age of 33 years (range 23 to 61 years). All worked for Lonmin Plc in Rustenburg: 19 at Karee Mine, 10 at Western Platinum Mine, and four at Eastern Platinum Mine (the name of the mine was unknown for one of the mine workers).

As shown in Table 1, the majority of the 34 mine workers were buried in the Eastern Cape province (n = 26; 76.5%). We have assumed that they came to Marikana from that province to work on the mines. One (2.9%) was buried in Gauteng province, and only two (5.9%) were buried in the province in which the mines are located (North West province). Five of the mine workers (14.7%) came from neighbouring countries.

Most of the mine workers were rock drill operators (n = 18;
54.5%) of whom 13 (72.2%) came from the Eastern Cape (Table 1). Three of the remaining 13 mine workers from the Eastern Cape were winch drivers; two were stope workers; two were general miners; and one was an equiper. Four of the five mine workers who came from neighbouring countries, were rock drill operators. Only two miners (5.9%) were recruited locally from the North West province: one was an equiper and the other was an engineer helper.

The job descriptions of three of the mine workers were unknown; all were from the Eastern Cape. One of these mine workers was a contract worker. Although the precise nature of his work was unknown, it was noted he worked in a high dust environment, and had been employed at Western Platinum mine for 10 months. No other employment information was available.

Pathological findings at autopsy

**Silicosis**
At autopsy examination, three of the mine workers had silicosis, with nodules in both lungs and the peribronchial lymph glands (Table 2). Two of the three had mild silicosis and were previously employed in the gold mining sector. The third mine worker had silicosis with PMF. He was the contract worker for whom little employment information was available.

Many of the mine workers (n = 18; 52.9%) had previously been employed in the gold mining sector. Twelve of these men (66.7%) were rock drill operators, one of whom had also worked in a chrome mine for six years.

An additional four miners had silicotic nodules in the regional glands only; three had been previously employed in the gold mines. However, the fourth mine worker might have also been a former gold miner as there were gaps in his employment history: he died aged 34 years after working for less than nine years as a platinum mine worker.

The majority of mine workers with silicosis and or inactive PTB at autopsy had previously worked in the gold mining sector (Table 2).

**Pulmonary tuberculosis**
Inactive pulmonary tuberculosis (PTB) was noted in two of the mine workers at autopsy. One also had silicotic nodules in his lungs and both had worked in the gold mines before being employed on a platinum mine.

**Other findings**
Other findings at autopsy included mild emphysema (n = 2), fibrous pleural adhesions (n = 2), changes characteristic of smoking (n = 2), and bilharzia (Schistosoma) ova in the lung (n = 1).

**Certification**
The mine worker with inactive PTB and no silicosis at autopsy had previously been certified as having compensable PTB in life (case 8). Two other mine workers (both previous gold mine workers) were also certified as having compensable PTB in life but no PTB was diagnosed at autopsy (cases 4 and 9) (Table 3).

The contract worker (case 1) had extensive disease, warranting first degree certification (pulmonary silicosis and PMF). He was not diagnosed while alive. The other two mine workers in whom pulmonary silicosis was diagnosed at autopsy were also not diagnosed during life, but their silicosis was less severe and may therefore not have been evident on radiological examination. One of the two also had foci of inactive PTB at autopsy.

In life, three mine workers had been sent for assessment to the MBOD: two with active PTB (cases 4 and 8) and one for a review of the radiological findings of fibrosis (case 9). The first had no PTB at autopsy, and the second had minute foci of inactive PTB. The third mine worker had no disease at autopsy, confirming the findings of the MBOD assessment panel after it had reviewed the radiological findings while the mine worker was alive.

**DISCUSSION**

**Silica-related respiratory disease**
Although a small group, these 34 mine workers provide some insight into the health of workers currently employed

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Table 2. Pathological findings of silicosis and/or PTB at autopsy by known employment history (n = 8)

<table>
<thead>
<tr>
<th>Employment history</th>
<th>Silicosis in lungs &amp; glands</th>
<th>Silicosis in glands only</th>
<th>Inactive PTB only</th>
<th>Inactive PTB + silicosis in lungs &amp; glands</th>
</tr>
</thead>
<tbody>
<tr>
<td>Platinum only</td>
<td>1†</td>
<td></td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Platinum + gold</td>
<td>1</td>
<td>3</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

† Contract worker (diagnosed with pulmonary silicosis and PMF)

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Table 3. Diagnosis and certification of silicosis and/or PTB

<table>
<thead>
<tr>
<th>Case</th>
<th>Disease(s) diagnosed at autopsy</th>
<th>Disease(s) diagnosed in life</th>
<th>Certification</th>
</tr>
</thead>
<tbody>
<tr>
<td>1†</td>
<td>Silicosis – lung &amp; glands</td>
<td>After autopsy</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Silicosis – lung &amp; glands</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Silicosis – lung &amp; glands</td>
<td>Inactive PTB</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Silicosis – glands</td>
<td>PTB</td>
<td>In life</td>
</tr>
<tr>
<td>5</td>
<td>Silicosis – glands</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Silicosis – glands</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Silicosis – glands</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Inactive PTB</td>
<td>PTB</td>
<td>In life</td>
</tr>
<tr>
<td>9</td>
<td>Nil</td>
<td>Lung fibrosis</td>
<td>None</td>
</tr>
</tbody>
</table>

† A contract worker
on platinum mines in South Africa. The main finding from the examination of the respiratory organs at autopsy was silica-related pathology. This was severe enough to warrant certification for compensation in one mine worker. Seven of the 34 mine workers (20.6%) had concentric fibrosis in the lymph glands; three (8.8%) also had pulmonary silicosis. Silicotic nodules in the lymph glands are indicative of exposure to silica dust, most probably during previous employment in the gold mines. Most of the men had records of having worked in the gold mining sector. Comprehensive employment histories were not available for two and they might have also previously been gold mine workers. Nelson and Murray (2013) found lower rates of silicosis and fibrosed lymph nodes at autopsy in a large group of platinum miners, viz. 12.7% and 2.2%, most but not all of whom had been employed in the gold mines.

**Cross-recruitment**

The recruitment of silica-exposed workers into an industry in which silica dust exposure is not a major risk factor for disease has resulted in silica-related pathology in currently employed platinum mine workers, which has the potential to increase the prevalence of PTB. Cross-recruitment within the mining industry is often from gold to platinum mines. Thus, workers exposed to silica dust, with disease or the potential to develop disease, may be employed in the platinum mining sector.

**Contract workers**

Workers with clinical or pre-clinical lung disease may also be recruited to work in the platinum mines through the contract labour system. Contract workers, many of whom are migrants, are especially vulnerable in terms of limited access to social, health and other services. The most diseased mine worker was a migrant labourer from the Eastern Cape. The only employment history available was that he had worked on the platinum mine for 10 months prior to his death. However, he was 53 years old and it was very likely that he had been exposed to silica dust in the gold mines. Despite his extensive disease, there was no evidence that he had been diagnosed in life, and was thus not considered for certification with first degree compensable disease until an autopsy was performed.

**Gaps in work histories**

Available records could only provide information about the last 10 months of the contract worker’s life, highlighting the problem of incomplete work histories recorded by many mining companies. These ‘gaps’ in mine workers’ employment records may compromise deceased mine workers’ families in claiming financial compensation for occupational diseases contracted by the workers while employed on the mines because disease cannot be attributed to exposure. It may also limit research which attempts to establish associations between exposures to specific mineral dusts and the development of disease.

**Pulmonary tuberculosis**

HIV/AIDS and silica dust exposure are the two main drivers of the PTB epidemic in the mines. An analysis of the prevalence of silicosis among deceased gold miners and ex-miners from 1975 to 2007 demonstrates a failure to control silica dust in the gold mines. Silica dust in the South African gold mines has always been a health hazard. The Milner Commission (1902 – 1903) identified the importance of preventing the small particles of silica becoming airborne. Gorgas, reporting a decade later, said that laying the dust in the mines was the remedy for silicosis and later, the scientists working at the South African Institute for Medical Research (SAIMR) showed that miners and ex-miners died of PTB grafted onto “silicised” lungs.

**High rates of migrancy**

Alexander et al. (2012) state that most Lonmin mine workers were oscillating migrants, mainly from Pondoland in the Eastern Cape. Therefore, we have presumed that the province or neighbouring country where the burials took place was the place of origin of the mine worker. Only two of the 34 deceased mine workers were buried in the North West province. Five were buried outside South Africa.
and the majority (n = 26; 76.5%) were buried in the north eastern part of the Eastern Cape, a primary labour-sending area for the mining industry, approximately 1 000 km from Rustenburg. Thus, 31 of the 34 mine workers (91.2%) were migrants, indicating that the migrant labour system persists, together with the associated social, economic and health implications.16

**Bilharzia**

The mine workers at Marikana are at risk not only of contracting occupationally-related diseases. One of the 34 mine workers from the Eastern Cape had bilharzia (Schistosoma) ova in his lungs. He may have contracted this in the Eastern Cape. However, there is evidence for a risk of infection with bilharzia in Marikana, the presence of which is reported by the Bench Marks Foundation to be “a direct consequence of informal settlements, a major cause of which is the housing policies of mining companies, and failure to maintain and repair sewage and drainage systems by Local Government.”17 The Report states that the residential conditions under which Lonmin and other mine companies’ workers live are “appalling”, and cites a proliferation of shacks and informal settlements, the deterioration of infrastructure and broken drainage systems spilling directly into the river.

**Benefit of the autopsy programme**

The autopsy programme at the NIOH has been instrumental in enabling mine workers’ families to receive financial compensation to cover loss of earnings from death due to compensable occupational respiratory disease. It is run by a team committed to assisting mine workers’ families to claim compensation under the Occupational Diseases in Mines and Works Act.2 In addition, the data clearly demonstrate the rising prevalence of silicosis and PTB in both the gold and platinum mines.4 The data can be used to analyse occupational respiratory disease trends in all commodities. Disease surveillance, using the PATHAUT data, enables policymakers to monitor the impact of strategies implemented to improve the health of mine workers. However, ongoing maintenance of the PATHAUT database and the continued support of the autopsy system by stakeholders are essential in order to ensure maximum benefit for research, surveillance and administrative purposes.

**Recommendations**

There are lessons to be learned from this tragedy, not only with respect to industrial relations. The cross recruitment of silica-exposed workers into an industry in which silica dust exposure is not a recognised problem has resulted in the manifestation of silica-related pathology in platinum mine workers. Platinum mines need to introduce carefully designed screening and surveillance programmes for workers previously exposed to silica dust. The recruitment of former gold miners whose lungs may be assumed to have...
been thoroughly “silicised” requires provision for careful entry examination and planned surveillance of a sub-group of the workforce at high risk of developing silicosis, PTB or both.

The majority of the platinum mine workers in this study were migrants. The migrant labour system compounds the health and economic burden of these workers. The health and social needs, and access to health services, of migrant workers need be addressed to reduce the vulnerability of this large and important group of workers. Contract workers must receive the same medical benefits as permanent workers across the mining industry, including participation in medical screening and surveillance programmes.

The Department of Mineral Resources needs to introduce policies that will make the recording of comprehensive work histories, both within and outside the mining industry, by the mine medical services, mandatory.

It is the obligation of every mining company to inform its workers about the Occupational Diseases in Mines and Works Act, to adhere to the requirements stated therein, and to assist mine workers' families with the procedures for submission of the cardio-respiratory organs for autopsy examination, which include providing complete employment records.

More research on occupational diseases is needed in the platinum mining industry, in line with that conducted in the gold mining industry, to aid efforts to improve the overall health of these mine workers.

Limitations
Autopsies were conducted on a small sample of platinum mine workers from a single company, but the reported findings nevertheless highlight issues that are currently experienced by all mine workers in South Africa. The rates of disease are not generalisable to all platinum mine workers but the purpose of this paper was not to estimate disease prevalences.

CONCLUSION
Many factors add to the burden of ill health of platinum mine workers. The Farlam Commission of Inquiry will examine the roles of Lonmin, the South African Police Services, Trades Unions, the Department of Mineral Resources, and individuals in the tragic events that occurred at Marikana on 16 August 2012. This paper provides evidence from the autopsy records of miners killed on that day for some additional underlying factors, namely, high rates of disease, cross recruitment between...
A micrograph of a section of lung stained with haematoxylin and eosin, showing bilharzia ova

Photo courtesy of Dr Naseema Vorajee

mining sectors, the contract labour system, and migrancy, which may add to the health, social and economic problems of platinum mine workers. These issues persist, despite extensive research, primarily in gold mine workers, and subsequent recommendations and policies designed to alleviate the problems.

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CONFLICT OF INTERESTS
One of the authors (GN) is an editor of Occupational Health Southern Africa. However, this author played no role in the peer review process. There are no other conflicts of interest.

LESSONS LEARNED
1. Silicosis in platinum miners, much of which remains undiagnosed in life, is primarily due to exposure to silica dust in the gold mines.
2. Recruitment across mining sectors is common.
3. Employment records in the mining industry are often incomplete.
4. Migrants continue to work on the South African mines.
5. Contract labourers are a vulnerable group of workers.

REFERENCES