Commentary

Occupational lung disease in the South African mining industry: Research and policy implementation

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Abstract South African miners face an epidemic of occupational lung diseases. Despite a plethora of research on the mining industry, and the gold mining industry in particular, research impact (including disease surveillance) on policy implementation and occupational health systems performance lags. We describe the gold mining environment, and research on silicosis, tuberculosis, HIV and AIDS, and compensation for occupational disease including initiatives to influence policy and thus reduce dust levels and disease. As these have been largely unsuccessful, we identify possible impediments, some common to other low- and middle-income countries, to the translation of research findings and policy initiatives into effective interventions.
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Introduction

One hundred and twenty years after the discovery of gold on the Witwatersrand in 1886, mining remains a major force in the South African economy. Despite policy and legislative reform, partly informed by extensive research, 16 years into a democratic South Africa, gold miners in particular face an epidemic of occupational lung diseases. This provides an occupational health context in which to examine the impact of research on policy implementation and occupational health systems performance. This article outlines the gold mining environment, presents disease burdens, describes initiatives to reduce disease, and concludes with factors that may have impeded effective interventions, some common to other countries.

The Gold Mining Industry

Although well below the half million employed in the 1990s, South African gold mines still employ approximately 160 000 people.[1] The industry is characterized by male cross-border and internal rural-urban migrants who leave their families and live mostly in single-sex mining compounds, returning home for variable periods.[2] Until 1975, work contracts were temporary and short, but labour arrangements stabilized thereafter and duration of service increased.[3,4] These social circumstances and stabilization have contributed to serious inter-related epidemics of silicosis (silica dust-induced scarring of the lung),[5] tuberculosis (TB), and HIV infection in miners, in surrounding communities and in labor-sending regions.[2] Post-apartheid reforms deracialized legislation, but race remains an important determinant of occupation, salary, housing, and disease burden.

Surveillance and Research

In South Africa, surveillance of occupational exposures and diseases is weak notwithstanding efforts of the Department of Mineral Resources to maintain registers such as the South African Mining Occupational Diseases database, initiated in 1998.[6] The Pathology Automation System (PATHAUT), an electronic database of approximately 100 000 autopsies of deceased miners, dating back to 1975, is a striking exception. Although provision for compensation for occupational lung diseases to current and former miners and their families in life and after death has been in place since 1911, the Occupational Diseases in Mines and Works Act of 1973 catalysed the development of the database by the South African Medical Research Council.[7] PATHAUT provides a rich data-source for research and monitoring disease trends.[8,9] Universities and research entities, some partially funded by the state or from levies on industry administered by the state, filled gaps in data, on black miners in particular, in the 1990s and 2000s, showing rates of disease previously unappreciated. Silicosis demonstrates these aspects well. Importantly, the proportion of black gold miners found to have silicosis at autopsy increased from 3 per cent in 1975 to 32 per cent in 2007. Key studies describing silicosis prevalence in gold miners (Table 1) show substantial disease burdens into the late 2000s, with no evidence that interventions have reduced these to acceptable levels.

Biologic and social factors combine to create a 'perfect storm' for the interaction among silicosis, TB, and HIV. Thus, integrated, multifaceted remedies are required to control these epidemics. Silicosis substantially increases the risk of TB[19–22] to a magnitude similar to that of HIV infection.[23] Importantly, silica exposure is associated with TB even in the absence of silicosis[20,24] and the increased risk is lifelong.[24] Risk factors such as migrancy[25] and single-sex compounds increase high-risk sexual behaviour,[26,27] and thus HIV rates, which are close to 30 per cent among these miners.[28] The TB risks of silicosis and HIV infection combine multiplicatively.[23] Consequently, the highest recorded rates of TB worldwide have been reported in South African gold miners.[29] Mortality from TB is higher than that from mine accidents.[30,31] The prevalence of TB in gold miners has increased from 806 per 100 000 in 1991 to 3821 in 2004.[32] HIV prevalence rose from less than 1 per cent in 1987[33] to 27 per cent in 2000.[28] More recent data, after the roll out of antiretroviral treatment in 2003, are not available.

There is a large body of research on the control of TB in South African mines that addresses the use of isoniazid therapy to prevent TB in people with HIV;[34–36] the spread of TB in the mining environment;[37–41] and TB case finding.[42–44] Studies have evaluated clinical management,[45–47] and delayed, missed, or inaccurate diagnosis of TB in life[28,48] that have added to TB transmission. Drug resistance[37,49,50] and recurrence of TB[41,51–53] have also complicated control. Researchers and occupational health practitioners have developed materials to assist mine health-care workers with TB management.[54,55] The Mine Health and Safety Council, a tripartite body formed under the Mine Health and Safety Act of 1996, and comprising representatives from the Department of Mineral Resources, the mining industry, and trade unions, funded and published the work. Neither the Council nor any other organization has formally measured the uptake of the materials but anecdotal evidence suggests that they are not widely used.

The migrant labour system has weakened incentives to control dust and disease by externalizing costs of disease, moving them away from the gold mining industry to communities and the State.[2,56–61]

Table 1: Silicosis prevalence in gold miners, 1940–2007

Authors	*Study design*	*Study period*	*Study population*	*Mean employment (years)*	*Diagnostic tool*	*Proportion (%)*
Hnizdo and Sluis-Cremer[10]	Cohort	1940–1991	Deceased white gold miners	23.5	Chest X-rays	14.0
Murray *et al*[11]	Trend analysis	1975–1991	Deceased black gold miners	4.8	Autopsy	9.3–12.8
Murray and Hnizdo[12]	Cohort	1940–2003	Deceased white gold miners	23.5	Autopsy	51.6
Steen *et al*[13]	Cross-sectional	1994	Living black ex-miners	15.5	Chest X-rays	26.6–31.0
Trapido *et al*[14]	Cross-sectional	1996	Living black ex-miners	12.2	Chest X-rays	22.0–36.0
Meel[15]	Cross-sectional	1997–1999	Living black ex-miners	—	Chest X-rays	34
Churchyard *et al*[16]	Cross-sectional	2000–2001	Employed black miners	21.8	Chest X-rays	18.3–19.9
Girdler-Brown *et al*[17]	Cross-sectional	1999	Living black ex-miners	25.6	Chest X-rays	24.6
Park *et al*[18]	Cohort	1999–2000	Living black ex-miners	26.1	Chest X-rays	27
Nelson *et al*[4]	Trend analysis	1975–2007	Deceased black gold miners	13.4	Autopsy	3–32

South Africa requires multifaceted public policies to address this negative impact of migrancy that is common to many low and middle-income countries. Bilateral agreements between countries to provide industry-funded health services for former miners in labour-sending areas is one example. Another is patient-retained medical records to improve continuity of care for migrant workers.[62] Accompanying this are failures of the occupational disease compensation system. Barriers to compensation are considerable and the majority of qualifying claimants have not received awards (Table 2), thus reducing the substantial financial incentive to control dust that would be brought

Table 2: Studies of occupational disease compensation processes and outcomes in miners employed on South African mines

Study	*Context*	*Study period*	*Outcome*
Steen *et al*[13]	304 former gold miners living in Thamanga, Botswana	1994	Very few miners with occupational lung disease had been compensated (proportion not specified)
Trapido *et al*[14]	238 former gold miners living in Eastern Cape, South Africa	1996	62% of those eligible not compensated. Only 2.5% fully compensated
Murray *et al*[64]	All 2530 miners who came to autopsy	1999	446 cases (19%) had occupational lung disease not identified and submitted for compensation in life, or more severe disease than had been compensated in life. 31/446 (7%) of families had received benefits by April 2001
Roberts[65]	205 former miners, Eastern Cape, South Africa	2008	175/205 (85%) reported not receiving the statutory medical examination when leaving the mine (which is partly to identify compensable disease). 203/205 (99%) did not know of the Compensation Act and its benefits
Maiphetlho *et al*[66]	84 former mine workers diagnosed with silicosis at Groote Schuur Hospital, Cape Town, and submitted for compensation	1993–2005	17/84 (20%) recorded as having received compensation. Median time from submission of medical records to receipt of award was 51 months (range 22–84 months)

about by compensation payments and hence increased levies on mines. Trapido *et al*[63] estimated the unpaid occupational lung disease compensation for gold miners to be 10 billion South African rands (US$1.4 billion; $1 = R7) in 1996, closer to 20 billion rands (US$2.9 billion) today. Even in poor countries, investments in compensation systems should bring greater returns in reduced disease burdens and their attendant costs to the public health system, provided that compensation costs are borne by industry.

Policy, Legislative and Service Initiatives

Although the history of disease reduction initiatives dates back to the early 1900s, these cannot be seen in isolation from South Africa's apartheid history of racial discrimination.[67] We describe attempts to achieve control of silica dust, reduced impact of migrancy, improved housing, and better TB management and compensation systems necessary to reduce disease burdens. In 1973, the Occupational Diseases in Mines and Works Act (ODMWA) provided compensation for occupational diseases for miners, but benefits were substantially higher for white miners than other groups. The 1993 Amendment to ODMWA established racial parity in compensation benefits but access to benefits is unsatisfactory (Table 2). In Table 3 we summarize key initiatives in the last two decades and comment on their outcomes.

The 1994 Leon Commission of Inquiry into Safety and Health in the Mining Industry, whose recommendations were informed by evidence presented by the National Union of Mineworkers, researchers, and activists, has had far-reaching consequences. The inquiry led to promulgation of a modern and comprehensive Mine Health and Safety Act with ancillary tripartite structures (representation of labour, government, and industry), such as the Mine Health and Safety Council (MHSC), to promote, develop, and oversee policy, standards, and encourage relevant research. However, neither the state, academics, nor trade unions have evaluated the impact of this law on practice.

Government has not implemented its long-standing policy of improving compensation benefits for miners (under the auspices of the Department of Health), in line with those available to non-mining workers (under the auspices of the Department of Labour), probably because of the increased and unfunded costs.

Numerous initiatives have sought to address living conditions of miners, but progress has been slow.[68] A substantial body of applied research to reduce silica dust and disease[69,70] coincides with widely published targets (milestones),[71] the establishment of task teams to disseminate good practice, and campaigns by stakeholders. There is, however, limited evidence of sustained reductions in silica dust levels.[72,73] Translation of research into practice has been patchy; for example, MHSC-sponsored research-based materials to raise awareness and skills among practitioners, miners, health and safety representatives, and managers[71] have not been disseminated by the MHSC, mining houses, or trade unions.

Efforts of mine medical services to control TB in the mines have had limited impact.[62] Although the mining industry has made substantial progress in developing HIV and AIDS programmes for miners,[74] there is little evidence of declining HIV rates. Despite research and numerous policy initiatives, South Africa's mining industry falls short of compliance with health and safety legal requirements, as demonstrated by the Department of Health,[73] the AIDS and Rights Alliance for Southern Africa,[75] and a Presidential Audit of compliance[76] reports.

Barriers to Translating Research into Action

The mining industry, the state, trade unions, and academics have done scant formal critical analysis of factors that have impeded effective interventions to reduce disease.[77] In the absence of this analysis, we have identified financial, social, and organizational factors with face-validity that might explain much of the failure to implement translation of research and policy into action (Table 4). Many of these factors could apply to other countries.

Conclusion

Scientific studies have motivated and informed many sound policy decisions and legislative reforms, and have identified strategies for strengthening practice and health systems. South Africa has adopted some recommendations, but very few studies seem to have fostered sustained remedial action. There are clear gaps between research, policy, and implementation in occupational health practice in the South African mining industry.

Table 3: Policy, legislative and service initiatives affecting miners in South Africa: 1993–2010

Year	*Initiative*	*Primary responsibility*	*Comment*
1990s to present	Substantial body of research initiated and sponsored by Mine Health and Safety Council, notably the Silicosis Control Programme, to improve measurement and control of dust and awareness of the diseases and the roles of workers, management, and practitioners	Department of Mineral Resources	Important findings widely disseminated but scant evaluation of impact on practice and limited availability of key research-based tools
1993	Amendment to Occupational Diseases in Mines and Works Act to provide uniform compensation benefits, irrespective of race	Department of Health	Did not achieve purpose because of failure to award benefits to the majority of qualifying claimants, and to make benefit examinations accessible to former miners in the labour-sending areas
1993 to present	HIV/AIDS research and numerous tripartite engagements and summits. Widespread implementation at large mines of comprehensive programmes on HIV and AIDS, including prevention, treatment, community outreach, and evaluation	Department of Mineral Resources, Department of Health, academics, mining industry, trade unions	Consensus on principles and policies achieved and national and industry plans formulated. Business case for action widely accepted. Little evidence of declining HIV rates
1994	Leon Commission of Inquiry into Safety and Health in the Mining Industry to recommend measures to improve mine health and safety	Presidential Inquiry	Swift incorporation of many recommendations into law, but no published analysis of impact of these regulatory reforms
1995	Mine Health and Safety Act with subsequent amendments, regulations, codes of practice, guidelines, and standards	Department of Mineral Resources	Modern comprehensive Act. Impact not formally evaluated but probably limited by relative focus on accident prevention, poor data on exposures and occupational lung diseases, and weaknesses in enforcement of dust control and measures to reduce lung disease

1999	Task-force to integrate the occupational health and compensation systems in the country, partly to improve compensation benefits for miners	Department of Labour	Separate systems for mining and non-mining industries persist. Contested domains of authority and unfunded liabilities may explain lack of progress
2005	Social Contract for Rapid Housing Delivery partly to reduce single-sex compounds	Department of Housing	Some progress but 51% of gold miners still housed in shared single-sex dwellings in 2007
2009	Housing and Living Conditions Standard for the South African Minerals Industry to provide standards and tools for monitoring and evaluation	Department of Mineral Resources	Promulgated, but not yet implemented
2003	Formulation of milestones (targets) to reduce silica dust and eliminate new cases of silicosis in mining	Department of Mineral Resources	Extensively publicized and endorsed; task teams established to promote attainment. Insufficient data to evaluate progress
2003	Guidance Note for Occupational Medicine Practitioners: Tuberculosis Control Programmes. Detailed guide to assist employers in preparing a comprehensive TB control programme	Department of Mineral Resources	Excellent recommendations but, to date, no evaluation of implementation published and Guidance Note not updated as stipulated
2007	Tuberculosis Strategic Plan for South Africa 2007–2011 outlines key role of mining and importance of dust control and improved living conditions in TB control	Department of Health	Weak intersectoral collaboration among government departments limited impact

Table 4: Factors influencing translation of research findings and policy initiatives into effective interventions to reduce disease

Factor	*Comment*
Financial and other resources	
Unknown cost of disease reduction	Mining industry, government departments, or other agencies have not done any cost analysis, but costs perceived to be high
Compensation system weaknesses	Low compensation costs limit the financial incentive for the mining industry to reduce dust and disease
Declining industry	Government departments may redirect their attention to growing industries
Competing demands for limited resources	Other public health concerns of the Department of Health and the mining industry may override occupational disease, eg the rapid escalation, scale, and the complexity of the HIV epidemic overtook existing infrastructure, policy formulation, and programme development capacity
Social	
High rates of migrancy	Integral to southern African economies but poorly developed government solutions to reduce impact as a disease-driver
Unequal power relations among social partners	Trade unions under-resourced (finance, knowledge, etc) to contribute adequately to self-regulatory tripartite model of Mine Health and Safety Act
Limited civil society activism	Weak occupational health and safety non-governmental organizations
Organizational	
Fragmented occupational health system	Domain-contestation among Departments of Health, Labour, and Mineral Resources inhibits formulation of integrated national policies and appropriate resource allocation
Weak inspectorate in the Department of Mineral Resources	Capacity directed to safety issues
Poor monitoring and evaluation	Inadequate information on dust levels and disease burdens, and evaluation of enterprise-level programmes and impact of policies/legislation has prevented identification of effective interventions. Government policies do not identify agencies responsible for monitoring and evaluation and/or allocate appropriate resources
Focus on accident prevention	Immediacy of injuries and traumatic deaths reduces focus on the more insidious impact of disease mortality, by all role players

Mining is growing in southern Africa and in many low- and middle-income countries. Other countries could avoid the high levels of occupational diseases experienced in South Africa through an enhanced understanding of the implications of the failure to use research evidence. Key messages to other countries are to: monitor dust and disease levels reliably, evaluate the impact of policy and regulatory reforms, and define the roles and responsibilities of individual government departments and other agencies clearly.

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