



Occupational health and safety in mining—status, new developments, and concerns

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Synopsis

This paper examines the occupational health and safety performance (OHS) of the South African mining sector against the backdrop of changes in the composition of the sector, international trends in OHS performance, and the agreement on OHS milestones and targets by mining stakeholders at the Mine Health and Safety Summit of 2003. Although OHS performance has improved, progress is slow and there is need for significant rather than incremental change if the targets are to be realized. Since 2003, fatalities and injuries are 20–25% short of annual milestones and not all commodities show consistent improvement. Statistics on occupational health impacts are unavailable, but noise and respirable dust levels are known to be high in mines, with much work lying ahead to address exposures at source. Trends in regulating and addressing OHS hazards are discussed with reference to the notion of 'systems-thinking' and the targets. Efforts to improve OHS and to respond to changes in the sector are constrained by a lack of training and consistency in risk management, guidance for junior, small and artisanal miners, and holistic approaches to risk. For example, treating risk holistically would involve taking proper account of contractors and women in the workplace, and attending to human factors and ergonomics.

Introduction

Occupational injuries and ill-health have huge social and economic implications for individuals, their families and their communities. They also have economic impacts in the form of direct and indirect costs for society as a whole. Total costs of occupational accidents and disease have been estimated at between 1 and 3 per cent of GDP in various countries^{1,2}. Direct costs include compensation costs, costs associated with damage in the workplace and the costs of interruption of production. Indirect costs include the costs of livelihoods lost, income to dependents, and the cost associated with care-giving by families and the community. Poor communities tend to bear the brunt of externalized indirect costs, but today mining companies can also suffer loss of reputation and withdrawal of investment capital.

In the broader context of sustainable development, healthy and safe working

conditions are among the first expectations for sustainability, i.e. the expectation that risks in mining will not deprive workers of their livelihoods or of their quality of life.

Occupational accidents and health hazards can also affect public health and safety, and the environment. These factors, the effects on the health and safety of people, costs to the economy and impacts on the environment, link efforts to address occupational health and safety to the broader social agenda for sustainable development.

The accident and ill-health record of the mining sector compares poorly to that of other economic sectors such as manufacturing, construction and rail, leading to mining's reputation as the most hazardous industrial sector. Mine environments are especially challenging because they can degrade fairly rapidly and they change as mining progresses. Dust and noise are inherently associated with rock breaking, and in underground mines, air and light must be supplied artificially. Blasting, as well as mining itself, releases harmful gases into the underground environment. Ergonomic hazards are common in mining as miners generally handle heavy equipment and do heavy work, often in cramped conditions. In some instances ergonomic hazards, which are associated with poor engineering design, contribute to increased safety risks. An example from South African mines is the positioning of the driver's seat in many of the locomotives still used in haulage—at the back of the vehicle and at right angles to the direction of travel.

South African mines currently employ about 460,000 workers and contribute significantly to GDP (7.1%)³, exports (34% of value)⁴ and formal employment (6.5%)⁵. Most workers are employed in gold and platinum mines in Gauteng and the North West

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Occupational health and safety in mining—status, new developments and concerns

Province. Mining also has a multiplier effect on the rest of the economy, which, when taken into consideration, raises the contribution of mining to the GDP to close to 12%⁶. Given the importance of mining to employment and in the economy, there is significant value in addressing health and safety systematically.

When mining started on an industrial scale in the 1880s, miners faced very high levels of risk to both safety and health. Over the years the safety performance of mines improved, but not at the same rate as at in other major mining countries such as Australia, Canada and the USA. It is difficult to compare health performance. In 1995, the Commission of Inquiry into Mine Safety and Health concluded on the basis of a number of studies that exposures to dust in mining had remained unchanged for 50 years. The Commission attributed this to an absence of systemic approaches to controlling respiratory disease⁷. In recent years, changes in legislation, better appreciation of the relationship between silica exposure, TB and HIV/AIDS, and commitments made by industry stakeholders have resulted in fresh efforts to reduce health and safety risks. However, comprehensive initiatives to control health exposures are still new and in development. Since exposure data for airborne pollutants and noise indicate that risks to health are serious, they are likely to remain so until effective control strategies are implemented across the sector.

Recent developments such as increasing numbers of contractors working on mines, the emergence of 'junior' mining companies, the recognition of small-scale and artisanal mining, and the presence of women in mining pose new challenges for health and safety regulation and practice, for example:

- ▶ With more contractors and contracting companies on site, occupational health and safety management is more complex. Given the need for contractors to quote competitively for work, tensions between health and safety goals, and production outputs are heightened. In 1999, the number of subcontractors employed in the industry was estimated at 10%⁸.
- ▶ Many junior mining companies lack the resources of their larger counterparts to identify best practice for health and safety, and to develop comprehensive approaches to risk management.
- ▶ Until recently, artisanal and small-scale mines, which play a role in poverty alleviation by providing employment, were not catered for in South African mining policy. About 20 000 small-scale and artisanal miners are active in the country⁹. Small scale and artisanal miners often lack business management skills, awareness of the legal requirements for mining and the means to address health and safety risks.
- ▶ Women in mining face greater risks to their safety than men because they use machinery, tools and equipment that have been designed for men. Furthermore, given that the physical demands of mining are matched to physiology of a select group of men, women face increased risks of injury and ill-health.

Mine safety

The International Labour Organisation (ILO) estimates the annual number of work-related fatalities that occur world-wide. Among the figures published by the ILO are estimates

of the number of work-related fatalities in South Africa. According to the ILO 1 908 workers in total died in work-related accidents in 2001¹⁰. In the same year, 288 workers died in mine accidents¹¹. Given that miners account for fewer than 500 000 workers (less than 4% of the total workforce) in the national workforce which is nearly 14 million strong, a disproportionate percentage of work-related fatalities (approximately 15%) are associated with mining.

Table I sets out the numbers of fatalities and fatality rates per million hours worked in South African Mines in the last four years¹².

In contrast to these relatively high rates, in Australia in 2003 (the most recent year for which data are available) the fatality rate was 0.05 fatalities per million hours worked, and corresponded to the deaths of 12 miners¹³. Comparison of Australian and South African rates suggest that miners are 4–5 times more likely to lose their lives in mine accidents in South Africa than in Australia. A major difference between South Africa and other major mining countries is the depth of gold mines, the labour intensiveness of gold and platinum mining, and the large number of workers on a single mine (the last presents significant organizational and logistical challenges). In contrast, Australian mines are more mechanized and fewer people are directly exposed to mining hazards. The fatality rates of the South African coal sector are more comparable to the national rates for Australian mines, reflecting greater similarity in mining methods and conditions.

It is estimated that the safety performance of the South African mining industry must improve by at least 20% per year to reach by 2013, the average performance of Australia, US, and Canada (Ontario)¹⁴. In 2005 the best ever improvement in one year, 16%, was achieved¹⁵. Figures 1 and 2 show how the safety performance of gold and coal sub-sectors of the South African mining industry changed over time¹⁶. For gold mining (Figure 1), the fatality rate declined sharply from 1904 to 1922. From then on until 1943, the rate of improvement slowed. From 1944 to the present day improvements continued slowly and were punctuated by several reversals corresponding to years in which mine disasters occurred. The overall trend in injury rates (steep rise until 1943 and then a steep fall until 1988) cannot be easily explained, and suggests incompleteness in the data.

The steep peaks that punctuate the downward trend in the fatality rates in Figure 2, for coal mines, clearly show the effect of mining disasters on fatality rates (sharp reversals in safety performance in years in which disasters occurred). The trend in the injury data suggests incompleteness, as is the case for the gold sector.

Table I

Annual number and rate of fatalities in mining 2003–2006

Year	Number of fatalities	Fatality rate per million hours worked
2003	270	0.29
2004	246	0.25
2005	202	0.21
2006	191 (provisional)	0.19

Occupational health and safety in mining—status, new developments and concerns

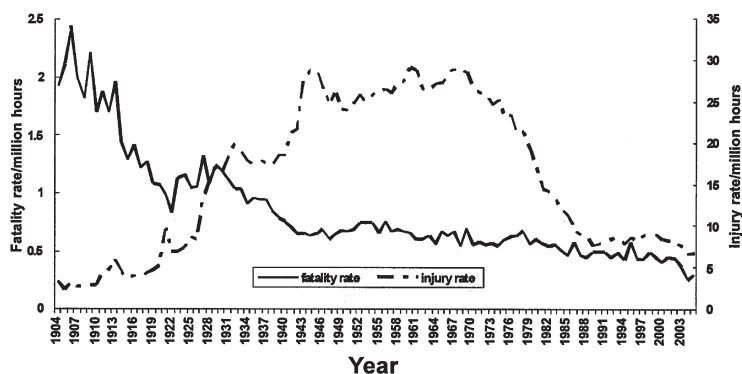


Figure 1— Fatality and injury rates in South African gold mines

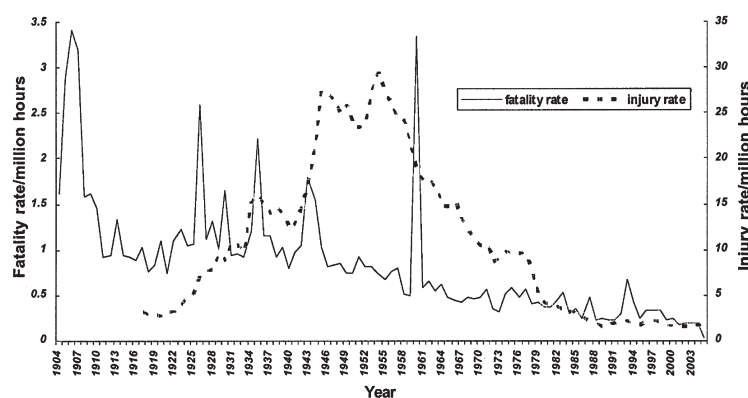


Figure 2— Fatality and injury rates in South African coal mines, 1904–2005

Safety data published by the Department of Minerals and Energy (DME) only includes data on fatalities and injuries that result in workers being away from work for at least 14 consecutive days. In short, the data are restricted to serious accidents and these are mainly associated with falls of ground, transportation, and machinery, approximately 30%, 20% and 7% respectively in 2006¹⁷. Analysis of this data suggests that the major causes of fatalities tend to be the same as those for serious injuries, while disasters have a different profile. In the last decade, mining disasters were associated with explosions due to flammable gases, a conveyor belt fire, an inundation of mud and water, and rock bursts. There is, however, another large category of accidents that is non-specific, entitled 'general', which confounds analysis of accident trends. This general category accounts for 40% of all accidents, most of which result in non-fatal injuries, and includes slips and falls, and hand injuries.

Some of the interventions that have over the years contributed to reducing safety risk levels include:

- standards for explosives used in mining
- administrative control of explosives underground
- stone-dusting in coal mines
- flame-proofing of equipment
- improved cap lamp technology and control
- improved ventilation systems
- installing explosion-proof walls to seal off mined out areas
- explosion barriers
- regional support systems in seismically active mines
- hydraulic props and other forms of active roof support.

Current ideas on addressing safety (and health) emphasize the role of leadership in setting clear OHS expectations, leadership's role in aligning business and OHS goals, proactive risk management based on leading indicators, communication, and responsiveness to feedback.

Mine health

Most countries do not have comprehensive sources of occupational health data. Much of the data are fragmented and when taken together, also incomplete. Exposure data, which can be predictive of disease, are particularly scarce and unreliable. This is because the requirements for representative sampling, sample analysis and data analysis are stringent and complex, and different criteria apply in different countries and industries. Reliability of the occupational health data is especially a problem in developing countries where reporting systems and reporting criteria are not well established. In 1999, it was conservatively estimated that world-wide there were 7000 000 deaths due to occupational disease, i.e. upwards of seven times more than the estimate of fatalities due to occupational accidents¹⁸. The ILO estimated that the total number of occupational disease-related deaths in South Africa was 8 229 in 2001. It is not clear how many of these deaths were associated with mining, although the available data suggest that the number would be significant and disproportional to the number of workers employed in mining and that there is a huge burden of occupational disease among former and current miners.

Occupational health and safety in mining—status, new developments and concerns

Major health risks encountered in mining include airborne pollutants such as silica dust and coal dust, noise, heat and vibration. Other significant health risks include chemical risks, which are not related to underground air pollutants or gases, skin disorders, ergonomic stresses, ionizing radiation and, in the diamond sector on the west coast of the country, decompression illness associated with diving. Although health risks can be avoided by implementing controls at source in the work environment, designing such controls for mining environments presents considerable challenges because dust and noise are generated by mining itself.

Other factors also raise the level of risk to health in South African mines. Approaches to dust monitoring delayed the recognition of the severity of the risks posed by airborne pollutants. Gravimetric dust sampling methods were introduced into the mining sector only in the late 1980s, and until then averaging of exposures measurements from diverse situations was commonplace. Added to the problem of recognizing the severity of health risks are the effects of changes in employment patterns and working hours on exposure time. For many decades after the start of mining in the country, miners worked on mines for limited periods before returning to the rural areas. It is possible that these miners left the industry before respiratory diseases such as silicosis became evident. By the mid-1980s, however, many miners remained in mine employment for more than two decades, suffering prolonged exposure to dust and developing occupational diseases in greater numbers¹⁹. More recently, the adequacy of protection systems designed around occupational exposure limits for eight-hour working days has been called into question. It is common in older mines for miners to spend 10–11 hours underground, with much of the extra time taken up by journeying to and from their workplaces.

Dust exposure

Studies on South African underground mines show that individual dust control measures can achieve reductions of between 25 to 50% of respirable dust²⁰. A range of control measures that act together to reduce exposure risks is therefore necessary. These could include methods for minimizing dust levels by reducing dust generation and methods for dilution, suppression, capture, and containment. Current guidelines on addressing airborne pollutants emphasize the importance of identifying and characterizing all sources of airborne dust, both primary and secondary, and properly integrating control interventions into procedures for choosing and maintaining equipment, and into the daily work cycle. While significant uncertainties remain in controlling dust exposures and maintaining the effectiveness of controls, the use of appropriate personal protective equipment (PPE) is important.

In recent years in the United States legal rules for verifying dust control plans in coal mines have been developed. At operational level it is expected that the following be checked before the start of shift: water pressures and water flow to dust suppression sprays on continuous miners; air quality and air velocity at the locations where machinery operates; dust collectors on drills and other equipment; and any other controls specified in mine ventilation plans. Should controls be found wanting, production must be halted until they are properly

functional²¹. Areas of research in the US to improve monitoring and control of dust, include real-time dust monitoring tools to check whether airborne dust is maintained within acceptable limits, improving dust collection units on machines through redesign and repositioning, and reducing dust levels within the enclosed cabins of older equipment by retrofitting dust filtration and pressurization units.

Noise exposure

Noise exposure is a widespread problem in mining because of the use of heavy equipment; drilling and rock breaking; transferring, sorting and milling of rock; and the confined working environment. Available data for noise exposure for South African miners suggest that nearly half the workforce is exposed to deafening noise, and of these workers more than 90% work in zones in which noise exceeds the 85 dBA time weighted average, with 11% working in zones in which the noise levels are even higher²². There were approximately 4 000 cases of noise-induced hearing loss in 2004 and approximately R75 million was paid out in compensation. As noise levels remain high in the sector and noise abatement interventions are still in development, PPE is very important in preventing hearing loss. In some working areas, noise levels associated with unsilenced pneumatic drills are so high (in excess of 115 dB (A)) that PPE cannot provide adequate protection. It is therefore likely that noise-induced hearing loss will continue among miners in the sector, and the number of compensable cases will rise again in the future when the threshold for compensable hearing loss is breached.

The South African situation is mirrored in mining environments elsewhere. According to the National Institute for Occupational Safety and Health (NIOSH) in the US, 80% of miners work in environment in which noise levels exceeds 85 dBA, 25% are exposed to noise levels above 90 dBA, and 90% of coal miners and 49% of metal/non-metal miners are hearing impaired by the age of 50.

Preventing hearing loss at present involves a range of strategies, which include engineering controls, education, surveillance and inventions to improve compliance to hearing conservation programmes. Examples of engineering controls adopted in mining to address noise include enclosure of equipment, dampening of noise vibrations, the redesign of equipment, and remotely controlled operations. Co-operative efforts involving the suppliers and manufacturers of equipment could bring far-reaching change if pursued on an industry-wide basis.

Respiratory diseases, tuberculosis (TB), HIV/AIDS and silicosis

In the period 1973 to 1993 (20 years) the Mineral Bureau for Occupational Disease certified 128 575 cases of occupational lung disease. The actual numbers of cases of disease is known to be higher, since black workers who are more likely to have been exposed to high levels of respirable dust, were not entitled to benefit examinations in the past. Today, occupational disease is still unlikely to be diagnosed among former mineworkers served by resource strapped clinics in rural areas. Information available on exposure to airborne health hazards suggest that, depending on the commodity under consideration, between 9 and 50 per cent of exposed workers, who account for about half of the workforce, are overexposed to airborne pollutants²³.

Occupational health and safety in mining—status, new developments and concerns

TB and HIV/AIDS are significant health risks in South African mining because these diseases are bound up with the living and working conditions of miners, such as migrant labour, single sex hostels, undiagnosed active TB, closed ventilation systems in underground mines, and dense living arrangements. Tuberculosis control is failing over much of sub-Saharan Africa, the region of the world most affected by HIV/AIDS, since HIV infection increases susceptibility to TB. The same effect is seen on mines. In addition, exposure to silica in mining operations together with HIV infection, multiply the risk of active TB. These combined factors also contribute to high rates of TB transmission. To reduce the TB on mines, TB must be identified early and treated, and both silica dust exposures and HIV infection must be controlled²⁴. Data sources, which are most reflective of the risk of respiratory disease in mining, are the records of TB notification cases collated by the Chamber of Mines and collected by the health services at mines. TB notification rates have increased rapidly since 1988 in the mining sector as a whole, but are particularly high for gold mines for which notification rates are three times higher than among coal and platinum miners²⁵. Figure 3 shows how TB notifications to the Chamber of Mines have increased over time. The proportion of TB cases involving HIV infection is also indicated in the graph. Gold mining TB rates are also well above the TB rates for the general population of South Africa. A large-scale intervention involving isoniazid preventative therapy (IPT) for TB is underway in the gold mining sector, which has the potential to reduce the risk of TB among miners by eliminating latent or recent TB infections, and reducing the possibility of subsequent infections²⁶.

The health and safety milestones

At the Mine Health and Safety Summit of 2003, the tripartite stakeholders in mining agreed to targets and milestones, which are aimed at addressing the major health and safety concerns of the sector. The milestones are considered to be the intermediate steps to achieving targets of zero fatalities and injuries, silicosis elimination and the elimination of noise-induced hearing loss. Current trends in the available data indicate that the sector is not achieving the level of improvement needed to reach the milestones. However, significant resources have been galvanized, for example, to share information, identify helpful existing technologies, develop new technologies, support technology transfer,

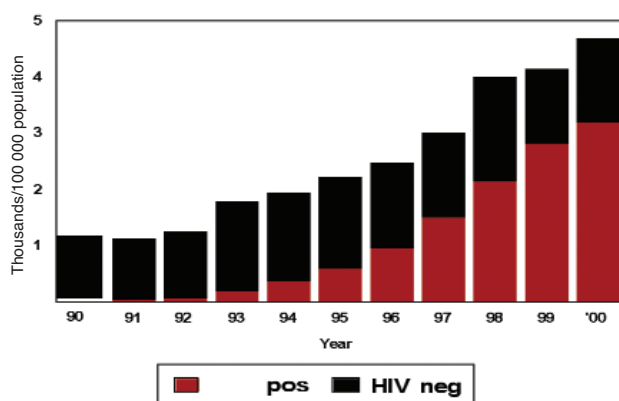


Figure 3—TB notification cases²⁷ (Source: Aurum Institute, Johannesburg)

closely monitor trends, and understand the role of leadership. These activities bode well for the future.

The three mining industry targets and their associated milestones are set out below.

The sector target for safety is zero fatalities and injuries. The milestones associated with this target are:

- *In the gold sector*—To achieve by 2013, safety performance levels at least (i.e. the average of the safety performance of mines in the US, Australia and Canada) equivalent to current international benchmarks for underground metalliferous mines
- *In the platinum, coal and other sectors*—to achieve by constant and continuous improvement, at least equivalent performance levels to current international benchmarks.

One of the sector's health targets is to eliminate silicosis. The milestones associated with this target are to:

- By December 2008, reduce 95% of exposures to below the occupational exposure limit for respirable crystalline silica of 0.1 mg/m³ (these results are individual readings and not average results)
- After December 2013, using present diagnostic techniques, cause no new cases of silicosis to occur among previously unexposed individuals (previously unexposed individuals are workers who would not have been exposed to silica prior to 2008, for example workers who are new entrants to the industry in 2008 or who have worked on mines or in occupations in which silica exposures were absent).

The second health target, which is also the final target of the sector, is to eliminate noise-induced hearing loss (NIHL). The present noise exposure limit specified in regulation is 85 dB (A). The milestones associated with this target are that:

- After December 2008, hearing conservation programmes must ensure that deteriorations in hearing are no greater than 10% amongst occupationally exposed individuals.
- By December 2013, the total noise emitted by all equipment installed in any workplace must not exceed a sound pressure level of 110 dB (A) at any location in that workplace.

Systems thinking and occupational health and safety

Questions have always been raised over how legislation can best influence OHS in the workplace, how OHS relates to other managerial responsibilities, whether the results of incident investigation can meaningfully support prevention, and how/why operations become vulnerable to small deviations in human behaviour. In recent decades the notion of systems has been helpful in developing answers to these questions²⁸.

A 'system' is understood as an aggregate of interrelated components that have an overarching purpose. Components may include policies, standards, institutions, people and machinery. An important characteristic of systems is that they are dynamic. They change when individual components change. Keeping a system aligned with its purpose and ensuring the systems respond appropriately to change requires conscious effort, for example responding to changes in employment patterns, working hours and management.

Occupational health and safety in mining—status, new developments and concerns

In systems, both the components and dynamics (within the components and between components) are important. For occupational health and safety, typical system components are stakeholder groups, OHS committees, policies, procedures, standards, specific accountabilities, auditing and monitoring protocols, and performance indicators. The dynamics of the system are provided by the actions and interactions of these components. This includes leadership, involvement, commitment, planning, consultations, interactions with regulators, responses to problems and acting on audit findings. Well developed system components can be an advantage but in the absence of good dynamics (e.g. commitment, involvement, feedback or responsiveness), system performance is likely to be sub-optimal²⁹. Today, evidence of systems thinking can be found in OHS legislation, workplace programmes and in approaches to stakeholder engagement, risk assessment and accident investigation.

Law

Mining legislation in South Africa and elsewhere developed piecemeal, usually in response to disasters involving loss of life and multiple injuries. The fact that safety risks are more manifest in the workplace than health risks has also skewed legislation towards safety and physical hazards. In practice in the long-term, however, more deaths and disability are associated with health risks than with safety risks. The period of latency between exposure to a health hazard and disease is one of the major reasons why health risks are underestimated or unrecognized.

In 1972, the report of a committee of inquiry into health and safety at work in Britain (the Roben's report), which was chaired by Lord Roben, laid the basis for more comprehensive and systemic approaches to health and safety. Roben criticized the bias in law and regulation towards safety and physical conditions; the absence of provisions for addressing health risks in the workplace; prescriptive legislation; and reactive approaches to developing law. He called for broadening perspectives on OHS to include consideration of the organization of work and human factors; ongoing engagement between employers and workers on health and safety, and employers' duties to manage OHS on a continuous basis. He also proposed that prescriptive legal provisions be replaced by performance or outcomes requirements, which were to be supported by a general duty of care placed on employers³⁰.

The Roben's report influenced the thinking of the ILO³¹, and the design of legislation in many countries, for example Britain, Australia, New Zealand, Norway and Sweden. In South Africa, the Commission of Inquiry into Safety and Health in the Mining Industry, which published its report in 1995, was also strongly influenced by the approach advocated by Lord Roben and by his concerns. The Commission recommended that legislation be promulgated to address occupational health in mines, and that mine employers take urgent steps to improve monitoring standards and practice, medical surveillance, and the control of health risks³². The Mine Health and Safety Act of 1996 (MHSA) arises out of the findings of the Commission and is enabling rather than prescriptive. Its main features are that:

- ▶ Employers bear primary responsibility for a safe and healthy work environment
- ▶ Risk management approaches to addressing health and safety hazards are mandatory

- ▶ Workers have rights to participate in health and safety, to health and safety information, to training and to withdraw from dangerous workplaces
- ▶ Tripartite institutions are charged with responsibilities to develop policy, legislation, regulations and promote a culture of health and safety.

In South Africa, all regulatory instruments for mines, e.g. regulations and codes of practice, tend to be framed as outcomes statements. In contrast in Britain, where performance-based approaches were pioneered, the approach of the Health and Safety Executive (HSE) is more nuanced. While the HSE generally follows a goal-setting approach, prescription is considered to be appropriate for certain situations. For example, mines are required to provide two exit routes in Britain. The HSE also requires licensing of inherently hazardous activities such as explosive use and asbestos removal³³.

Another international trend concerns the consolidation of all occupational health and safety legislation into single overarching statutes^{34,35}, as well as the amalgamation of the institutions responsible for OHS. This process is still being played out in South Africa³⁶, where a decision of the Cabinet in 1999 to harmonize and consolidate OHS legislation and institutions is under consideration, under the leadership of the Department of Labour.

Engagement

Workers have a fundamental interest in occupational health and safety because it is their health, lives and limbs which are at risk. A common observation in research and accident investigations is that workers have not been engaged in ways that enable them to inform management of specific OHS concerns, or to contribute their experiential and tacit knowledge of work and of OHS hazards. Adversarial or poor labour relations can rule out any form of partnership between managers and workers on health and safety³⁷ and can affect communication. The review of the 2005 accident at BP's Texas City Refinery, flagged as important willingness by managers to listen to the workforce and appreciation by the workforce of how safety considerations shape management decisions³⁸.

Another barrier to effective engagement may be managers' concerns that participatory processes will undermine their control of operations. Yet evidence suggests the contrary. For example an audit of the internal responsibility system in Ontario Mines found that: 'The workplaces in which workers and supervisors were involved heavily in planning the work, tended to be the mines where there were fewer accidents (as measured by medical aid cases)³⁹.

Risk management

Risk management processes are fundamental to the Mine Health and Safety Act and most other modern OHS statutes. The underlying premise of risk management is that improvements in health and safety can be made by correctly identifying and addressing hazards or factors (which may be underlying or direct) that contribute to occupational risk. The main components of risk management are hazard identification, risk assessment, implementation of controls, monitoring of controls, review, and adjustment or redesign of controls as necessary. The practice of risk management has led to understanding and appreciation of the following:

Occupational health and safety in mining—status, new developments and concerns

- Effective risk management is founded on good engineering design and systems of work.
- Where risk cannot be eliminated, control strategies can be designed to reduce the consequence or the likelihood of the risk (or both). An understanding of the impact of control strategies is important for both contingency planning and improving controls over time.
- When risk assessments are done too late, little can be done to avoid hazards.
- Complex work processes such as those with numerous interdependent activities and many levels of supervision, offer more opportunities for human error and equipment failure.
- To prevent deaths at work, severe risks must be eliminated or reduced, e.g. separating the travel paths of heavy mobile equipment from small vehicles or pedestrians, or using remote controls that enable people to stay out of hazardous areas.
- Risks are reduced by keeping low inventories of hazardous materials on work sites (e.g. low volumes of explosives or chemicals).
- Human beings are fallible, and designs should be tolerant of human failure and error.
- The factors that shape unsafe behaviours in the workplace, can be identified and eliminated or modified through appropriate interventions and changes in the overall system.
- Repeat accidents occur because the lessons of previous accidents are not learned or forgotten or are not passed on.

Accident investigation

Many theories of accident causation can be traced back to the work of Herbert Heinrich who studied 75 000 industrial accident reports in the 1920s. He concluded that 88% of accidents were caused by unsafe acts, 10% by unsafe conditions and 2% were unavoidable⁴⁰. Heinrich's theory (the domino theory) places the actions of workers at the centre of accidents. In South Africa this theory dominates thinking on accident investigation, but enhancements have been made to factor in risk management practice, and procedural and operational control. These enhancements and more recent approaches to accident causation recognize the 'multi-factoriality of the accident phenomenon'⁴¹ and include consideration of the organization of work, ergonomics, the work environment, abnormal working situations, process safety and the responsibilities of employers to provide safe systems of work and safe working environments.

Internationally, interest has shifted to applying systems theory to accidents. In systems theory accidents are viewed as 'flawed processes involving interactions among system components including people, societal and organizational structures, engineering activities and physical system components'⁴². Models based on system theory are non-linear and are unlikely to conclude, or reinforce the idea, that one cause, someone or something, is directly to blame for an accident. Instead they provide insight into the factors related to organizational structure, engineering design, manufacturing and operations that move systems into states in which small deviations from the norm can trigger catastrophes.

Constraints in the South African environment

Identification, assessment, elimination or control of risks is a tenet of the Mine Health and Safety Act, yet training in risk

management is not well established. In Australia where risk-based approaches are also rooted in law, such training is accredited by regulators in many states and risk management practice has become more standardized⁴³. In South Africa, the absence of consistent approaches to risk management is a concern.

Effective engagement among managers, supervisors and the workforce is vital to improving OHS performance. Unfortunately, South Africa's history of division along the lines of race, language, class, gender and educational opportunity presents significant barriers to building common cause around OHS, and creating open and responsive working relations. However, a number of examples of good practice exist, which could be documented, shared and emulated.

Contractors now perform a wide range of functions on mines from shaft sinking, to development work, mining itself, and other general work, but specific guidelines on contractor safety have not yet been considered, despite the vulnerability of contract workers. Reasons for this include incomplete data on the health and safety of contract workers, and the absence of systems to enable training and registration of contract workers.

Performance-based approaches in health and safety law do not meet the needs of companies that are small and underresourced, and that require explicit guidance on what is required of them. Greater appreciation of the circumstances of junior, small-scale and artisanal miners could support the development of appropriate OHS policy and intervention strategies.

The enabling approach of the MHS Act places more demands on regulators. Mine inspectors have to exercise professional judgement in many instances and cannot confirm compliance by simply comparing their observations against items on checklists. Programmes for the development and training of inspectors are important in addressing this concern.

Historically high-risk work has been assigned to men, and women have been excluded from such work. Work in the mining sector falls into the category of high-risk work. Reproductive hazards⁴⁴ in mining include ionizing radiation, inorganic solvents and toxic metals. For biological reasons, women may be more at risk from some of these hazards than men. Heavy physical work is also a reproductive hazard for women, and heavy work as well as equipment designed for men, expose women to more risks. More holistic approaches to risk management, which include consideration of gender implications of risk involving women workers in risk assessments, and rethinking approaches to ergonomic factors, if the participation of women is to be sustained in mining.

Conclusions

When mining started on a large scale in South Africa in the late 19th century, mine workers faced very high levels of risk to both safety and health. Over the years the safety performance of mines improved, but not at the same rate as mining countries such as Australia, Canada and the USA.

Given that the miners account for fewer than 4% of the total workforce in South Africa, a disproportionately high percentage of occupational deaths, 15% of the estimated total for the country, are associated with mining. Globally, the sources of data on occupational disease are fragmented and incomplete and exposure data is scarce and unreliable.

Occupational health and safety in mining—status, new developments and concerns

Nonetheless, in South Africa, the available data suggest there is a significant burden of occupational disease among former and current miners.

'Systems thinking' has strongly influenced developments in legislation, and approaches to risk management, accident investigation and worker involvement in health and safety. The full implications of this approach, which are entrenched in the Mine Health and Safety Act, have not yet been properly appreciated and incorporated into practice.

Constraints to improving OHS and responding to changes in the mining sector in South Africa include a lack of:

- ▶ Resources and guidance to address the needs of contract workers, junior, small and artisanal miners
- ▶ Training and consistency in risk management practice
- ▶ Holistic approaches to addressing risks by, for example, properly considering OHS risks to women, human factors and ergonomics; and
- ▶ Improving the quality of engagement between managers, workers and supervisors.

The sector's historical legacy of underestimating health risks constrains current efforts to improve OHS performance. The burden of occupational disease associated with past practice has not yet run its course. In the longer term, however, the impacts of current initiatives, which are mindful of the influence of TB and HIV/AIDS, should be beneficial.

The targets and milestones, which the tripartite mining stakeholders agreed to at the Mine Health and Safety Summit of 2003, are aimed at addressing the major health and safety concerns in the sector, and are driving more systematic efforts to address the causes of fatalities, injury and ill-health.

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