UNIVERSITY OF SOUTH AFRICA

PROJECT TITLE:

UNDERSTANDING THE OCCUPATIONAL HEALTH AND SAFETY MATTERS IN THE SOUTH AFRICAN MINING AND MINERALS SECTOR (MMS)

FINAL REPORT

FUNDING AGENCY:
MINING QUALIFICATIONS AUTHORITY (MQA)

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EXECUTIVE SUMMARY

This report was developed by the University of South Africa (UNISA) at the request of the Mining Qualification Authority (MQA). The primary objective of this project was to undertake a research study aimed at Understanding **the Occupational Health and Safety Matters in the Mining and Minerals Sector** (MMS). The Mining and Minerals Sector is comprised of sub-sectors that include Coal Mining, Gold mining, Diamond mining, Diamond processing, Platinum Group Metals (PGM), Cement, limestone, aggregates and sand (CLAS), Jewellery manufacturing, Services incidental to mining (SITM), and Other mining. The objectives of the study were as follows:

- Investigate factors that contribute towards fatalities in the mining sector.
- Explore factors influencing safety and health practices.
- Examine the nature of health and safety interventions in the workplace.
- Make SMART recommendations on how to ensure from a skills development perspective that safety and health matters in-built on organisational systems, organisational culture and production processes and practices to attain zero harm in the mining process.

The study provides practical recommendations for the MQA and other industry stakeholders to consider in order to address the current or future expected skills shortages and gaps in the MMS related to OHS skills.

Methodology

- The following methodology was applied in this study. Firstly, the population (i.e. mining companies) was stratified in terms of nine sub-sectors (i.e. Gold mining, PGM mining, Other mining, CLAS, SITM, Diamond mining, Coal, Diamond processing, and Jewellery manufacturing.
- Secondly, companies were categorised by entity-size into groups of small, medium and large sizes as per the MQA database.

- Thirdly, companies were then differentiated and grouped in terms of their geographical distribution within each sub-sector to identify the spatial representation of the industry.
- Lastly, a representative quota sampling technique was applied, with two businesses being selected for engagement from each sub-sector representing large, medium, and small business and balanced geographical spread. Caution was taken to minimise any likely threats to the veracity of the data, that may have arisen as a result of the deliberate or subconscious bias inherent in the quota sampling approaches that were utilised (Page & Meyer, 2000). In order to address researcher bias and other possible biases resulting from this sampling method, the companies selected and included in the study were randomly identified equitably across geographic/spatial continuum.

In acknowledgement of the limitations of time, two major stakeholder consultation workshops were carried out in January 2020 where we engaged key relevant stakeholders in MMS including all industry sub-sectors, the DMR, MQA, and labour unions. To complement the inputs from the consultation workshops, visits, and electronic and telephone interviews were conducted with more stakeholders. A total of 44 stakeholders from various MMS sub-sectors and stakeholder groups were engaged.

Findings

This study first established the main OHS issues still relevant in the MMS, a summative overview of which, is presented in the Table below:

Table: Summary of key OHS issues in main MMS sectors

Sub-sector	Key OHS issues in main MMS sectors
Coal Mining	• Rock falls • Coal dust explosions • Methane explosions • Machines coming into contact with persons • Fires from spontaneous combustion • Falling into or from excavations
Gold Mining	• Rock falls/ rock bursts as a result of mining depths • Machines coming into contact with persons in confined spaces falling materials and rolling rocks -Inundations by mud or broken rocks • Falling into excavations / from structures • Exposure to dust, gases, fumes - explosions and fires • Seismicity • High temperatures (up to 58°C if uncontrolled)
Platinum Group Metals (PGM) Mining	• Rock falls/rock bursts as a result of mining depths • Machines coming into contact with persons in confined spaces - falling materials and rolling rocks - inundations by mud or broken rocks • Falling into excavations/from structures • Exposure to dust, gases, fumes - explosions and fires • Seismicity • High temperatures (up to 58°C if uncontrolled)

As directed by the requirements of the MHSA, the main core skills areas of OHS Representatives, fall into three categories namely: Organisational, Human factor related and technical skills. These are summarised below using a framework first developed by Brun and Loiselle (Brun & Loiselle, 2002).

Table: Summary of OHS issues in MMS, skills required and qualifications

<table>
<tr><th>MMS OHS issues</th><th>Skills required</th><th>Qualifications</th></tr>
<tr><td>Organisational

Ensure OHS procedure and policy applied

Investigate accidents</td><td>Communication skills:

• Management skills
• Skills in understanding OHS policy and its application on mines
• Accident investigation skills
• Data collection skills
• Writing and reporting skills
• Pre-entry checks and documentation
• Procedures for underground rail systems to improve safety</td><td>Skills Programme in Occupational Health and Safety activities for :Part-Time/ Workplace Representatives and Shop Stewards in the Mining and Mineral Sector (MQA/SP/0120/10) composed of three main unit standards:

• SAQA 259622: Describe the functions of the workplace health and safety representative, 3 credits
• SAQA 244383: Conduct continuous hazard identification and risk assessment within a workplace, 2 credits
• SAQA 259369: Explain basic health and safety principles in and around the workplace, 4 credits</td></tr>
<tr><td>Human

Train workers in safe work methods. Training on PPE, HIV, TB, non-communicable diseases, emotional wellbeing

Discuss OHS issues with workers</td><td>• Disease monitoring and control
• Psychological skills
• Human behaviour skills
• Employee OHS capacity needs assessment
• Capacity development skills to train employees on PPE and other OHS issues</td><td>• Mine Safety Training (COMSOC 1, 2 and 3 by SAIOSH not accredited)</td></tr>
<tr><td>Technical

Research ways of resolving OHS issues conduct risk analyses</td><td>• Time management
• Conflict resolution
• Risk management skills
• Identify geological anomalies that could pose hazards in mines
• Monitoring implementation of</td><td>• National Certificate: Occupational Safety: Mining and Minerals level 5 (SAQA ID: 79828) (focus on occupational safety) SAQA ID 79828 is a certificate and 79829 is a diploma with very little</td></tr>
</table>

MMS OHS issues	Skills required	Qualifications
	Compulsory Codes of Good practices rail bound transport and trackless mobile devices • Skills in monitoring and testing noise hazards • Skills in air quality monitoring • Skills in heat analysis and monitoring • Analysis and monitoring of ergonomic factors such as vibrations, postures • Analysis and monitoring of seismicity, rock fall and fall of ground	uptake in institutions currently offering it. • National Diploma (SAQA ID: 79829) Occupational Safety: Mining and Minerals is registered at NQF level 5 • SAMTRAC (not a qualification but linked to unit standards-credit bearing) /COMSOC (not a qualification and also not linked to unit standards-non-credit bearing) • OFO Code 325705, **Mines Safety Officer** • Occupational Certificate: Safety, Health and Quality Practitioner registered at Level 5 for 256 credits (SAQA ID: 99714) - QCTO registered

Study findings revealed that, in order for the MMS to comply with the requirements for OHS in terms of the MHSA, there is a need for OHS representatives to possess certain skills as identified in the table above (table above is far broader than OHS rep requirements. It has some safety officer competencies in the table as well). This will allow the MQA to examine the implementation of OHS training programmes that are more holistic and include safety officers. The study further discussed wide-ranging OHS issues in the OHS in the MMS sector. Within this, the study specifically critically considers the skills and qualifications required to perform those roles in terms of the MHSA. The gaps in the sector and possible training programmes required to meet these gaps were also identified.

This study established that, currently companies address skills gaps through the following interventions:

- Outsourcing independent consultants.
- Offering bursaries.

- Providing in-house accredited training to staff and informal training programmes.
  - Taking staff on external courses such as COMSOC, DMR Blasting certificate, Skills Programme in Occupational Health and Safety activities for :Part-Time/ Workplace Representatives and Shop Stewards in the Mining and Mineral Sector (MQA/SP/0120/10, Health and Safety Environment (SHE).

Notably, this study confirmed that that some of these programmes have both low intake capacity and have low impact on the industry in relation to improvements in OHS outcomes. The MQA/SP/0120/10, Health and Safety Environment (SHE) programme has a scope outside of the MHSA and thus needs to be revised or replaced with more appropriate programmes.

Through stakeholder engagements, the study also confirmed that it was further established from stakeholders that industry representatives were interested and welcomed new relevant skills programmes that would enable them to comply with the MHSA.

Additionally, the study confirmed that there was a requirement for institutions to offer skills development programmes that focussed on all aspects of OHS including technical, organisational and behaviour/human skills. The following figures summarise the range of possible skills required in each of the core areas.

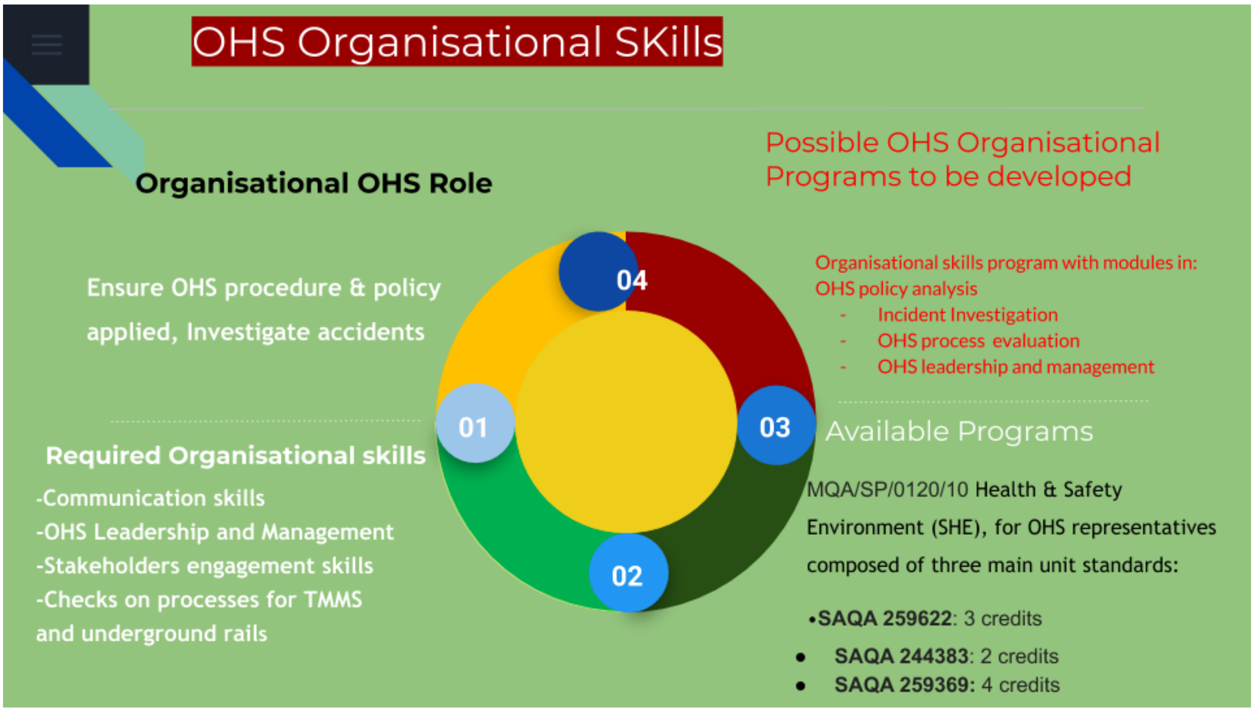


Figure: Summary of organisation skills

- Most of the required skills are available in SA but not incorporated into the current OHS skills programmes and qualifications in the SA markets.
- The industry identifies OHS skills as one of the skills in short supply according to the stakeholder investigation and the MQA sector skills plan 2018.

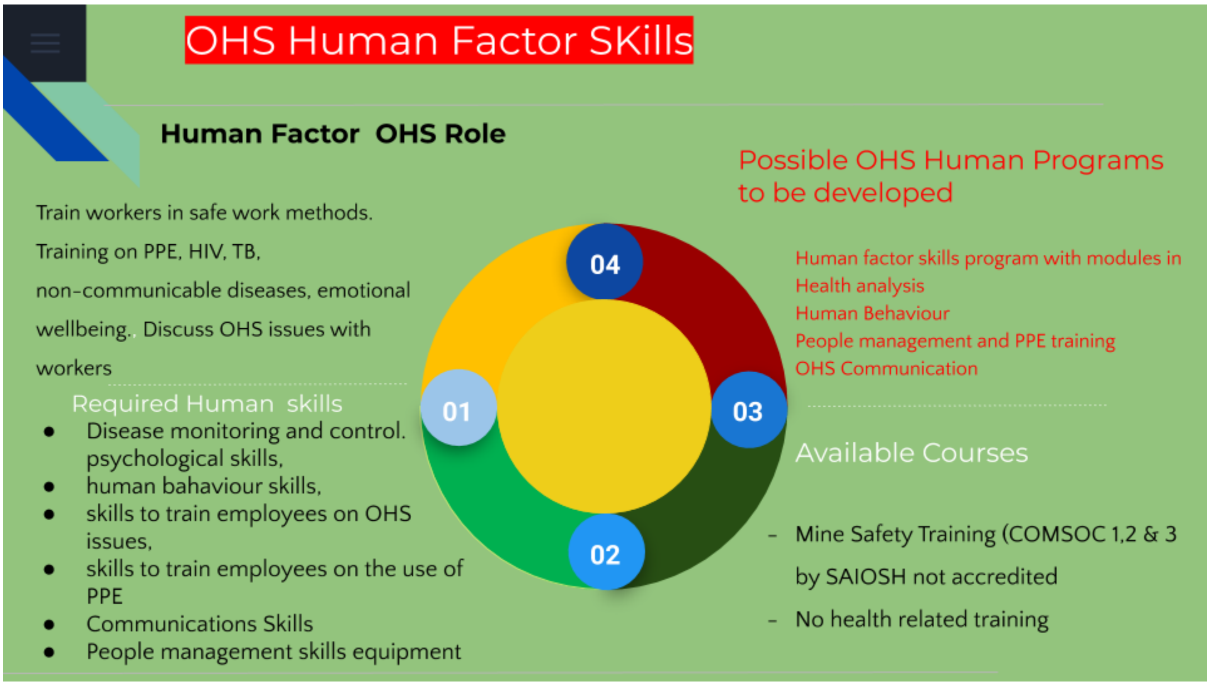


Figure: Summary of OHS human factors skills

1. There is a need to align the qualifications being offered through the QTCO requirements going forward. Basic education and quality of FET OHS programme also influences the supply of OHS skills.

- The supply of OHS skills is also influenced by the availability of accredited service providers who can assist in the implementation and quality control of these skills programmes.
- Technology and regulations are changing the way mining is done in South Africa and the world over.
- The mines of the future will require a high level of a combination of technology, human and organisational skills, to deal with OHS issues and progress towards zero harm.
- Certain MQA courses have not been adopted by industry and need to be reviewed, modified or replaced to ensure that they meet the requirements of the MHSA and industry.

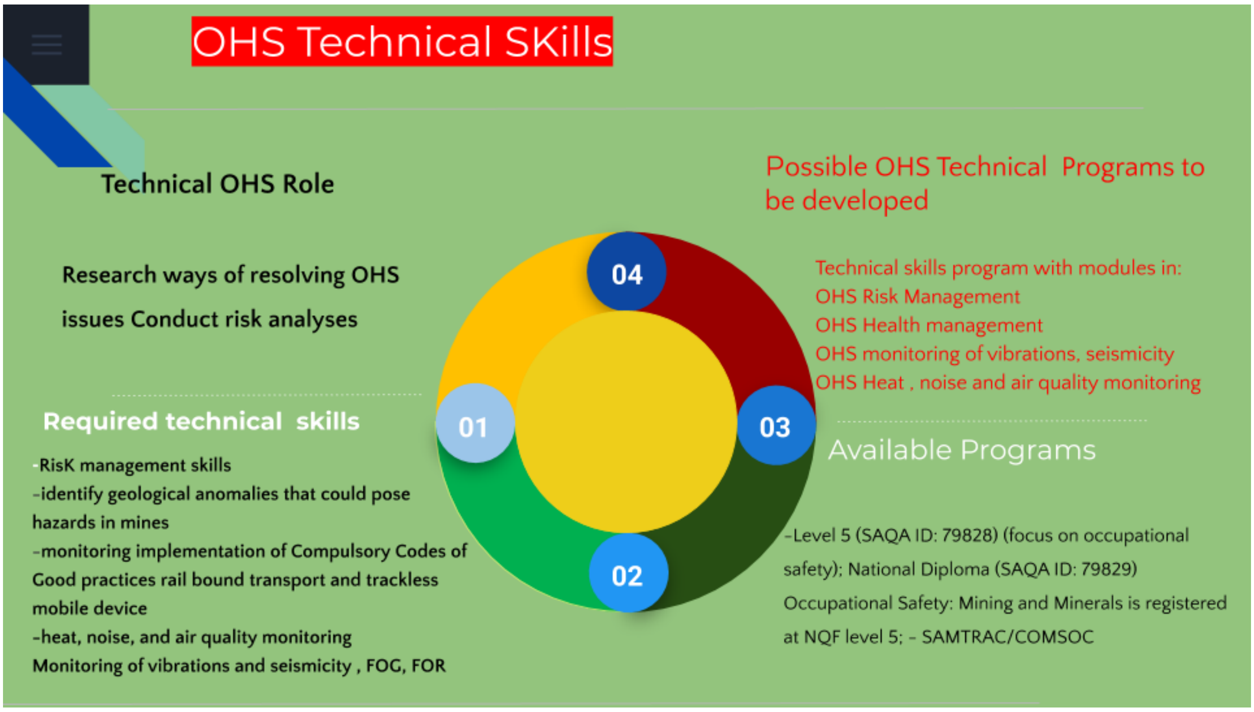


Figure: Summary of OHS technical skills

- All the mining sub-sectors are likely to experience an increased demand for various OHS related skills, considering that OHS skills are part of the critical investor and regulatory requirements and also, there will always be a need for OHS skills to fulfil legislative requirements related to safe and healthy mining.
- Given the economic, reputational and social cost of OHS issues, mines of the future will require good corporate citizenry, seek the relevant OHS skills and competences to ensure that they minimise their spending on compensation and also reduce reputational damage and any other negative impacts on the organisation and society.

The study also established that the demand and supply of OHS skills in the MMS is driven by various factors, some of which exude more pressure than others. The following figure summarises, in no particular order, the most prominent drivers of supply and demand of OHS skills in the MMS.

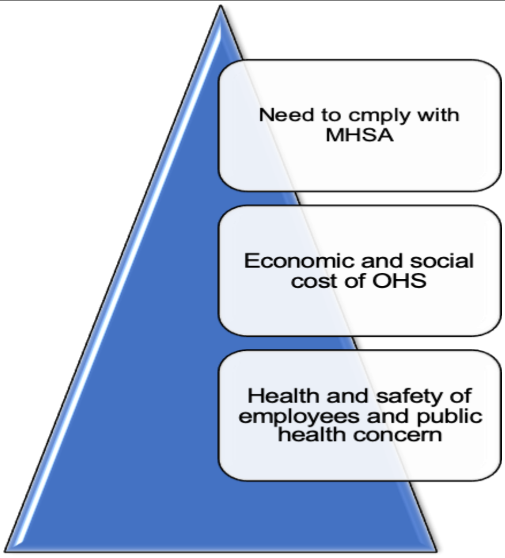
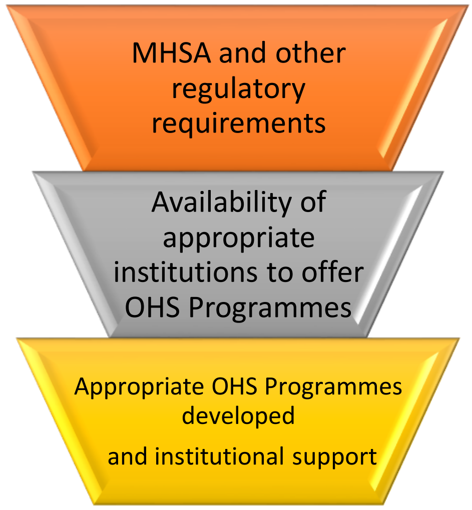
<table>
<tr><th>Demand of OHS skills</th><th></th><th>Supply of OHS skills</th></tr>
<tr>
<td rowspan="3">
</td>
<td>Technical OHS skills</td>
<td rowspan="3">
</td>
</tr>
<tr><td>Human/ behaviour OHS skills</td></tr>
<tr><td>Organi-sational OHS skills</td></tr>
</table>

Figure: Demand and supply drivers of OHS skills in the MMS

The study also draws attention to the career limiting impacts that arise from the fact that the MHSA specifies no minimum education or qualifications requirements for OHS representatives. Informed by this, there might be a need to review certain sections of the MHSA to strengthen the OHS requirements. Additionally, the study confirmed that current internships, apprenticeships, OHS learnerships and skills programmes offered in SA have limited human factor and health programmes among others. Institutions offering skills OHS programmes lack various organisational, human factor related and technical OHS skills programmes required to deal with OHS issues and to ensure that companies are compliant with the MHSA and work towards the “zero harm” goal.

Finally, technology advances continue to change the way mining is done in South Africa and due to changes in technology, different MMS subsectors are experiencing an increase in technology - enabling OHS skills to meet the legislative, investor related and social requirements of OHS in the MMS.

Recommendations

Based on the findings from this study, the following recommendations were made.

Figure: Summary of recommendations from study

1 **Revise existing OHS qualifications such as SAQA 74269** Health & Safety Environment (SHE) **to better align with the requirements of the MHSA and the needs of the MMS in relation to OHS skills**. The study revealed that there is a lack of alignment between the existing OHS programmes and the MHSA. The lack of alignment of certain courses to the MHSA resulted in limited uptake of these programmes.

2 **Audit current skills providers and ensure that the programmes offered are aligned to the needs of the MMS**.

3 **Work with other SETAs to incorporate certain existing programmes into the MMS**. It was realised that there are existing programmes in other SETAs that can be incorporated into the MMS to deal with OHS issues and to align with the MHSA.

4 **Align existing programmes with (QTCO which adheres to SAQA requirements)**. It was revealed that there exist certain OHS skills programmes including in-house programmes and other non-accredited programmes offered by certain service providers that can be developed further and aligned to qualifications.

5 **Examining in-house programmes offered by various companies in the MMS and develop some best practice OHS programmes from there**. Certain companies indicated that they have developed certain in-house programmes that deal with OHS issues and such programmes have worked in these companies especially in the December to January "silly season".

6 **Develop OHS career path in the MMS**. This study revealed that there are gaps in the process of appointing OHS personnel and the effectiveness of the role of OHS personnel in advancing role is further hindered by the lack of a clearly developed career path that can attract and retain the best OHS skilled people and offer them career development opportunities within the industry.

7 **Work with other SETAs, to incorporate certain existing programmes into the MMS to avoid duplications**.

CHAPTER 1

INTRODUCTION AND BACKGROUND

1.1 INTRODUCTION

The University of South Africa (UNISA) was appointed by the **Mining Qualification Authority** (MQA) to undertake a research study aimed at Understanding **the Occupational Health and Safety Matters in the Mining and Minerals Sector** (MMS). This chapter presents a broad introduction to the study including background, objectives of the study, methodology used and general structure of the report. This report is presented in five differentiated chapters. Chapter 1 presents an introduction and background to the study. Chapter 2 presents literature review on the various variables and concepts in this study. Chapter 3 presents the seminal strategic findings from the study. Chapter 4 presents stand-out messages from the study and finally Chapter 5 presents the key policy recommendations and the way forward. The next section presents a brief introduction to the study.

Various authors (Leitão & Greiner, 2016; Yilmaz & Alp, 2016) have concluded that occupational hazards cause harm to workers and negatively impact business activities through loss of revenue and increasing operational costs. Despite acceptance of the need to prioritise these negative effects, mines are yet to reach the point of zero harm (Müezzinoğlu, 2015). Globally, there is limited literature focussing on potential interventions and actions to ensure the reduction of occupational accidents in mines (Zwetsloot et al., 2017). In the case of South Africa, such literature remains scant with only a few peer reviewed articles on the subject. Even so, where such literature exists, it only offers a cursory examination of the issues specifically related to health and safety in mining in an integrated way that considers the relational issues between mining health and safety including injuries, diseases, and fatalities, and linking them to risk management and also skills development.

Research by some, including Virchow (2015) and Van den Honert and Vlok, (2015), points to the fact that, although mining is one of the riskiest industries globally, the situation is relatively worse in South Africa compared to comparable global contexts. In fact, according to van den Honert and Vlok, (2015), the death rate of one death per 300 workers related to accidents in the MMS in South Africa, is nearly double the worldwide fatality rate resulting from occupational hazards. In trying to understand issues in health and safety in the MMS, in South Africa various authors have examined various perspectives and variables including but not limited to (i) how co-worker safety and health support relate to safety and health performance; (ii) the role of leadership and management support for health and safety, and (iii) health communication (Moyo, Zungu, Kgalamono & Mwila, 2014). Studies also support the view that accidental events are cumulative and as such, proper risk management is required to ensure a reduction or total elimination of this scourge in the MMS (Gnoni & Saleh, 2017). It would be important for insights to be gained on how MQA skills development programmes can enable better risk management and accident/incident reduction in the MMS in SA.

1.2 CONTEXT AND BACKGROUND

The Mining Qualifications Authority (MQA) is a public entity established in terms of Section 45 of the Mine Health and Safety Act 29 of 1996 (MHSA) and is regarded as a Sector Education and Training Authority (SETA) in terms of the Skills Development Act 97 of 1998 (SDA). A mandate given to all SETAs is to facilitate the delivery of sector specific skills interventions that help achieve the goals of the National Skills Development Plan which replaced the National Skills Development Strategy (NSDS) III. The MQA together with the MHSC developed a concept paper to guide collaboration of the two entities in areas of research on issues of Health and Safety in the mining sector of South Africa.

Despite the urgent prioritisation and need for zero harm in the sector, there remains an intractable perpetration of health and safety shortcomings that lead to injury and/or death. Worryingly, there is neither clarity nor consensus on the extent or nature of Occupational Health and Safety Matters in the Mining and Minerals Sector. Informed by these and other sector limitation, the current research offers a foray into some of the key issues in occupational health and safety in the MMS in South Africa. Importantly, the study draws attention to linking identified sector flaws with skills development and the role of the MQA.

1.3 THE MMS SECTOR IN SOUTH AFRICA AND OHS ISSUES

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 percent of GDP in various countries**.** Direct costs include compensation costs, costs associated with damage in the workplace and the costs related to the interruption of production. Indirect costs include the costs of livelihoods lost, income to dependents, and the costs associated with caregiving by families and the community. Poor communities tend to bear the brunt of externalised indirect costs but today, mining companies can also suffer reputational damage 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, ensure that efforts to address occupational health and safety are interrelated 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. Though the mining sector is most rigorous in terms of reporting accidents/incidents, it remains one of the most hazardous industrial sectors due to the very nature of mining with most mining done in underground environments. 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.

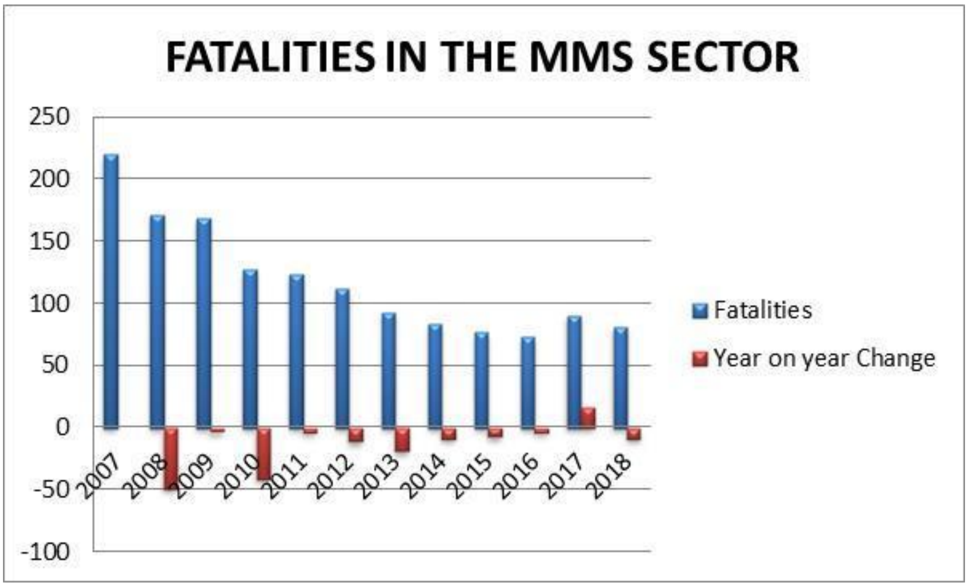


Figure 1.1 Fatalities in the MMS

(DMRE, 2019)

Figure 1.1 presents fatalities in the MMS between 2007 and 2018 in South Africa. According to these statistics there has been a significant reduction in the number of fatalities in the MMS sector between 2007 and 2016, though there was an exponential increase in 2017. That trend was reversed in 2018 and the figure for 2019 continues to reduce. Even so, within the global "zero-harm" goal, one miner dead is one too many. Therefore, there is need to continue to examine the issues in OHS in the MMS that continue to inhibit the sector from arriving at that zero-harm aspiration. This study presents a link between some the critical issues in OHS in the MMS and skills development highlighting the role of the MQA to deal with some of these issues. The next section briefly presents the SA economy and within this, the role of the MMS is specifically articulated.

1.4 STRUCTURE OF THE SOUTH AFRICAN ECONOMY AND THE SIZE OF THE MMS

The South African economy like any other middle-income economies is dominated by the financial services (20%) and other services (6%) industries. Mining now constitutes only 8% of the SA economy, a reduction from about 19% in the 1990s, while manufacturing constitutes 13%, trade 15%, and government 18%. The electricity sector represents 4% of the economy.

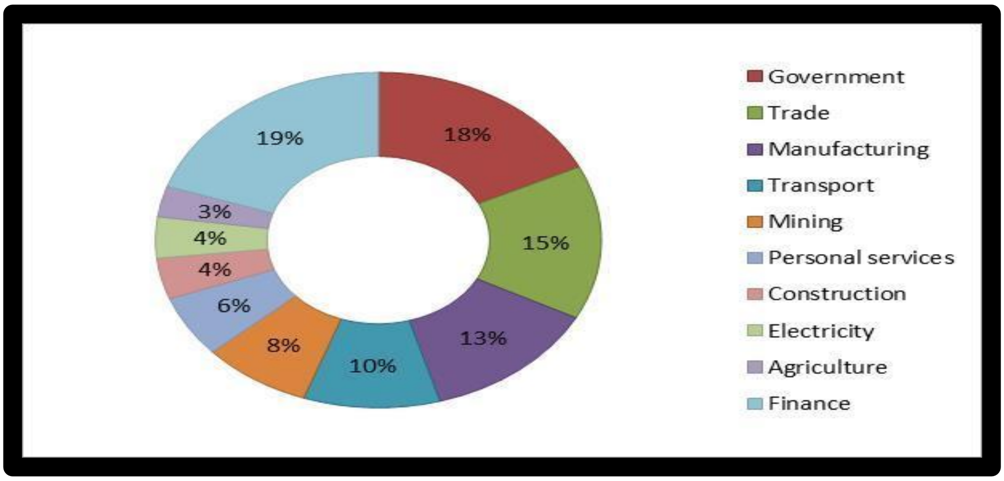


Figure 1.2 South Africa's economic sectors 2017

(Stats SA, 2018)

Though the MMS sector now consists of only 8% of SA's GDP, it remains an essential backbone of SA economy as it is a huge employer and mining products constitute inputs into various sectors: Manufacturing, electricity, among other uses. The composition of the different economic sectors in South Africa is presented in Figure 1.2. Because of the changing trends in the structure of the SA economy, trends within the MMS are also changing, especially as a result of the impacts associated with the contribution of technology and the depletion of certain mineral deposits.

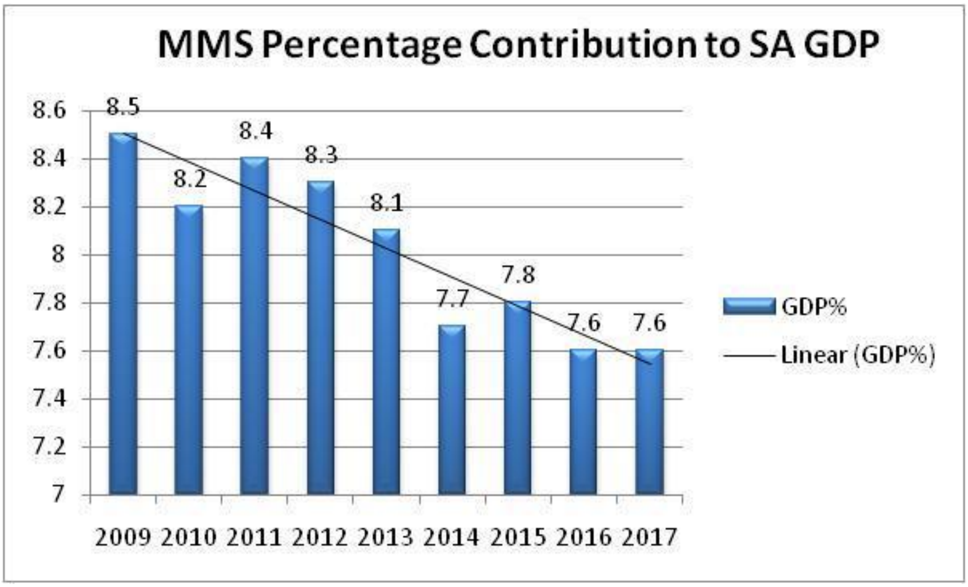


Figure 1.3 MMS percentage contribution to SA GDP
(Stats SA, 2018)

As illustrated in Figure 1.3 above, the MMS sector remains a significant and but continually decreasing contributor to SA's GDP. Accordingly, Frost and Sullivan (2011) argue that while South Africa has become a services-oriented economy, the direct contribution of energy-intensive primary and secondary activities which include manufacturing, mining, electricity and other utilities, and agriculture, remains significant. With increasing calls for the policy of beneficiation to be implemented in the MMS, there exists a potential for the MMS to contribute even higher value to the SA GDP. Even so, safety concerns remain a critical sector challenge whose negative impact could be countered by skills development toward the optimal goal of increasing production and achieving zero harm.

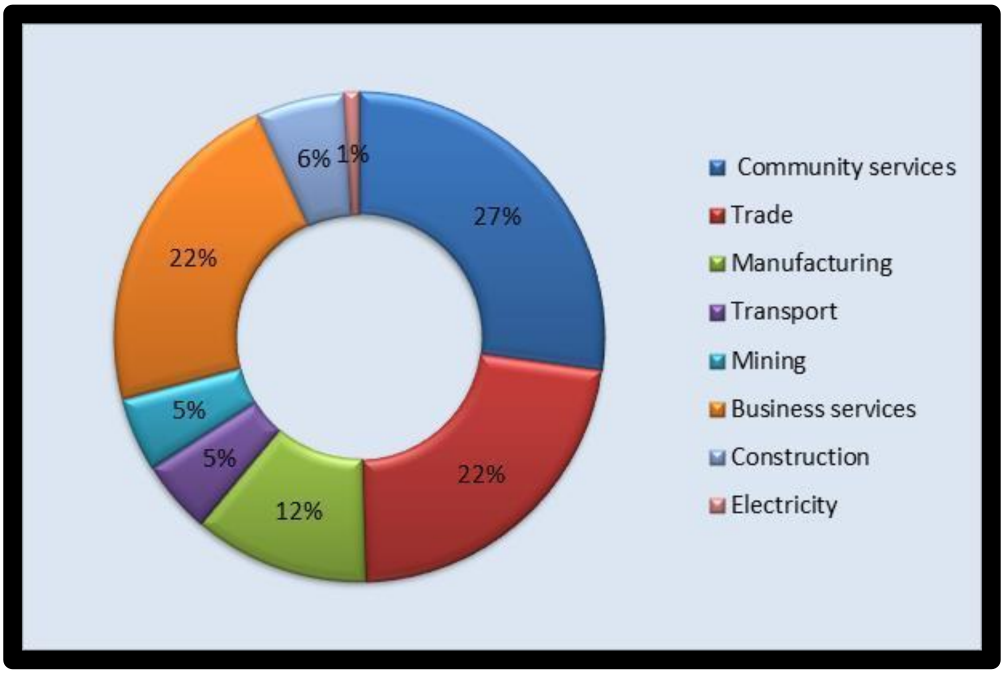


Figure 1.4 Contribution of different sectors of the South African Economy to Employment, 2017

(Stats SA, 2018)

The importance of any sector in the economy is dependent on its contribution to GDP or its contribution to employment. Figure 1.4 above, presents the sector contribution to employment in South Africa as of 2017. While sectors like Community Services and Trade do not contribute highly to GDP, their contribution to employment is highest. The services sector also contributes highly to both the nation's GDP and to employment.

Table 1.1 Geographic location of the MMS

Geographic location of the MMS			
Province	**Total companies**	**% MMS employers**	**% MMS employment**
Gauteng	1019	44.8%	31.0%
North West	281	12.4%	26.9%
Mpumalanga	281	12.4%	16.0%
Western Cape	216	9.5%	1.2%
Northern Cape	166	7.3%	4.1%
Limpopo	114	5.0%	15.2%
KwaZulu-Natal	98	4.3%	1.6%
Free State	58	2.6%	3.2%
Eastern Cape	41	1.8%	0.1%
Total	**2274**	**100.0%**	**100.0%**

(MQA, 2019)

According to Table 1.1 above, there is a total of 2274 companies in the MMS sector in SA registered with the MQA. Of these companies, nearly half (44.8%) of them are found in the Gauteng province and these contribute to 31% of employment in the MMS sector. Though the representation of mining companies is skewed towards Gauteng because most companies have their headquarters situated in Gauteng, it might be tempting to assume that most mining activities happen in Gauteng. However, for purposes of this study, the focus was to ensure that all sub-sectors of the MMS are included that way the study is not skewed toward a specific province.

The mining sector contributes 5% to employment in SA, in the face of decreasing employment in all sectors. As such, the 500,000 or more jobs contributed by the mining sector to the SA job market are very significant. There exists a potential to grow these jobs with beneficiation and development of other secondary and tertiary sectors. To maximally exploit this, it is critically important to understand how the different sub sectors in the MMS contribute to employment in the MMS and in SA.

Table 1.2 Profile of MQA registered companies by sub-sector

Profile of MQA registered companies by sub-sector						
Sector	**Small**	**Medium**	**Large**	**Total**	**% of total companies**	**% of employment**
CLAS	102	25	20	147	6.5%	1.90%
Coal Mining	148	27	55	230	10.1%	17.80%
Diamond Mining	38	6	18	62	2.7%	3.60%
Diamond Processing	59	4	4	67	2.9%	0.40%
Gold Mining	80	11	28	119	5.2%	20.20%
Jewellery Manufacturing	173	8	0	181	8.0%	0.40%
Other Mining	729	96	107	932	41.0%	13.70%
PGM Mining	6	3	23	32	1.4%	34.50%
Services Incidental to Mining	409	50	45	504	22.2%	7.60%
Total	**1744**	**230**	**300**	**2274**	**100%**	**100.00%**

Percentage	**76.7%**	**10.1%**	**13.2%**	**100.0%**		

(MQA, 2019)

As represented in Table 1.2 above, the majority of mining companies (41%) in SA are classified as belonging to the "other" mining category. It will be important for this category to be micro-analysed to develop further insights into what "other mining" is composed of. The proportion of the number of companies in other sub-sectors is also presented in the table above. The Mining Qualifications Authority (MQA) plays a vital role in skills development in the mining industry. The MQA developed its strategic priorities for the last year linked to the National Skills Development Strategy III (NSDS III) period and beyond, by developing the necessary skills development policies for the mining and minerals sector. The next section presents the scope of this study and the methodology used.

1.5 STUDY SCOPE

1.5.1 Purpose

The purpose of the research study was to gain more insight into health and safety matters in the MMS in South Africa.

1.5.2 Study objectives

The objectives of this investigation were as follows:

- Investigate factors that contribute towards fatalities in the mining sector
- Explore factors influencing safety and health practices.
- Examine the nature of health and safety interventions in the workplace
- Make Specific, Measurable, Achievable, Realistic, and Timely (SMART) recommendations on how to ensure (from a skills development perspective) safety and health matters can be meaningfully integrated with organisational systems, organisational culture and production processes and practices to attain zero harm in the mining.

To ensure the completion of above-identified objectives, both qualitative and quantitative methodologies were applied as depicted below:

1.6 RESEARCH METHODOLOGY AND APPROACH

This section presents the methodological process followed to implement this project. Guided by the research questions posed for the study, the investigation of health and safety matters in the MMS in South Africa also required qualitative exploration with respect to the supply and demand for skills that can improve health and safety within the eight MMS sub-sectors. Within this, there was identification of the commonalities among the sub-sectors to determine essential and scarce health and safety skills. The requirement for rich descriptive insights informed the selection of the descriptive and exploratory method approaches utilised as specified below:

- *Descriptive approach*, which involved a description of a phenomenon as it exists. This was applied to describe the situation with respect to the issues related to health and safety; analysis of the supply and demand for skills related to health and safety within the eight MMS sectors under review as.
- *Exploratory approach,* which sought to extract patterns or themes. This approach was used to determine the commonalities among different MMS sub-sectors in terms of the demand for various health and safety related skills and it also facilitated the identification of those that are essential and those that are scarce.

A review of the research questions listed in Annexure A, was used as the basis upon which the research team determined whether responses to particular questions would be derived from either or both primary and/or secondary data sources. While secondary information was identified as an important potential data source, it was clear at the onset of the study that much of the data required to respond to the questions was not in the public domain and could be most reliably elicited from appropriately sampled primary data sources. Guided by this, the project was executed following the process presented below:

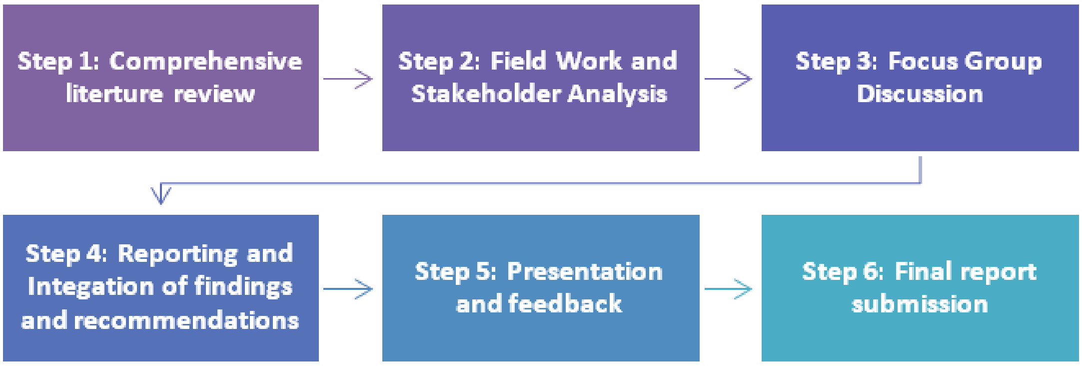


Figure 1.5 Approach and techniques to undertake study

Approach to sampling

The purpose of this step was to collect primary qualitative and quantitative data on health and safety matters to attain zero harm goal in the mines. This step involved various stakeholders and both facts and perceptions on the various variables related to the research questions were probed. This step was critically important to the development of the entire study as, quality of data and comprehensiveness of information collected affects the veracity of recommendations that could be provided to the MQA at the end of the project.

According to Walsh (2001), a sample is part or portion of a whole or subset of a larger set that is chosen or selected by a researcher to use in a research project. It includes the target population, sampling frame, sample size and method. The sampling plan and criteria for the project are summatively presented below and they included:

(a) The selection of companies was to be *representative of the geographical spread* of the businesses in the respective sub-sectors.

(b) Selection of companies that were categorised as *large, medium, and small businesses* to ensure consideration of challenges and demand implications across the continuum of all business sizes.

(c) *Three companies* were to be selected and engaged from each sub-sector.

Considering the above criteria, it was decided that a systematic stratified sampling approach would be used:

- Firstly, the population (i.e. mining companies) was stratified in terms of eight sub-sectors (i.e. Gold mining, PGM mining, Other mining, CLAS, SITM, Diamond mining, Diamond processing, and Jewellery manufacturing).
- Secondly, companies were divided into groups of small, medium and large sizes as per the MQA database.
- Thirdly, companies were then grouped in terms of their geographical distribution within each sub-sector to ensure spatial representation across the industry.
- Lastly, a representative quota sampling technique was applied, with two businesses being selected for engagement from each sub-sector representing large, medium, and small business and balanced geographical spread. Generalising the information acquired via quota sampling is can be problematic due to the likely existence of deliberate or subconscious bias exerted when selecting companies to be interviewed; thus, caution needs to be taken when interpreting the data (Page & Meyer, 2000). In order to address researcher bias and other possible biases of this sampling method, companies were selected and included in the study following a random sampling approach which factored geographic spread as a confounder.

The research team also attempted to deal with issues of low response rate from this study by interviewing more than one company and in given cases, three companies from certain sub-sectors were interviewed supported by further follow-up of respondents to improve response rates as outlined in Table 1.3.

Table 1.3 Description of companies engaged in the MQA project

Company	**Size**
CLAS	
Vergenoeg Mining	Medium
Gold Mining	
Ecrsteling Gold Mine	Small
Anglo Gold	Large
Coal Mining	
Mbuyelo Coal	Small
Glencor	Large
Diamond Mining	
SADPMR	Industry regulator
Diamond Processing	

Company	Size
Soweto Diamond Academy	Medium
SAPMR	Industry regulator
Jewellery Manufacturing	
Akapo Jewells	Small
Other Mining	
Nokeng Mine	Small
Glencor	Large
PGM Mining	
The Platinum Incubator	Small
Anglo American Platinum	Large
Services Incidental to Mining	
Ramodike services	Small
DMRE	Regulator
Zizwe mining Services	Small
TR Safety Consultants	Small

Data gathering approach and tools

As previously stated, both secondary and primary data was used in this study as no single data source could comprehensively answer the research questions under consideration.

Secondary data collection

This involved the sourcing and review of critical existing literature on occupational health and safety matters in the MMS. Local and international peered reviewed articles, policy documents, annual reports and various other relevant documents were reviewed. The literature reviewed set the scene for the rest of the study and provided the necessary reference framework for further analysis. It provided input variables that were used to develop the data collection tools.

The following key questions were answered during the literature review:

- Definition of key concepts in relation to health and safety issues in the MMS?
- Literature on fatalities on mines both locally and internationally?
- Literature on key change drivers that influence health and safety issues in the workplace? (technology, level of mining and so on)

- Literature on regulatory and policy issues such as government legislation, which are likely to have an impact on the sector with regard to health and safety?
- Literature on the root causes of fatalities? Determine if fatalities are a result of system failures or human capacity.
- Literature on skills interventions implemented to ensure safety and health in the workplace?
- Literature on how mine owners and managers are dealing with or responding to issues of health and safety on mines?
- Literature on the status of this intervention with regard to recognition? (accreditation)
- Literature on cost and investment in training interventions to reduce fatalities on MMS?
- Literature on drivers of health and safety matters in the workplace?
    - Literature on types of qualifications/skills programmes that takes into account the changing needs of technological developments in mines?
    - Literature on the status of these in terms of accreditation and rollout?
    - Are the currently existing skills SAQA registered programmes and listed as part of the new QCTO qualifications?
    - What are the gaps in terms of skills that are currently included under SAQA and QCTO qualifications?
    - What new qualifications will need to be developed to address the gaps?
    - What additional training/modules or curricular are required?
    - Which skills-related training should the MQA focus on?

Each of these factors were analysed to examine their past, current and possible future prevalence and to give us a picture of the state of the issues relating to health and safety in different subsectors of the MMS. Systematic situational analyses (for each of the eight mines sites in Coal Mining, Gold Mining, Platinum Metals Group (PGM), and Other Mining Commodity (Diamond, Iron, Manganese, Chrome, Copper and Quarries) sectors, was conducted using a modified version of Porter's Five Forces Analysis. In the final parts of this study we examined the possible factors that would influence the demand and supply of OHS skills and in this context understand the forces that would impact mines of the future assisted to analyse the possible OHS issues that might arise in the future and what skills programmes could be developed to deal with them.

Primary data collection

The collection of the primary data focused on answering key questions related to main areas on the matters relating to health and safety in the MMS: These included questions on factors that contributed to fatalities, factors that influenced health and safety practices in the workplace, nature of interventions used to reduce fatalities and improve health and safety in the MMS and the drivers of health and safety in the workplace with a focus on skills development and the role of the MQA. In order to implement the field work, a sample province with the highest concentration of resources in each of the sub sectors was selected accordingly.

A participatory approach was used in the administration of both semi-structured questionnaires and the interviews.

The questionnaire used in this study was agreed upon with the MQA and a copy is found in the Annexure A of this study. The use of semi structured questionnaires ensured that the collated data was specifically relevant in addressing the key research objectives. No incentives were given for participation in the study and both the study proposal and questionnaire were pre-submitted for ethics clearance with the relevant body.

Depending on the size of the company and the availability of the staff, the interviewed personnel represented the following occupations:

- Mine manager
- Health and Safety Managers
- Health and Safety Representatives
- Shift managers
- Skills development managers
- Employees/Unions
- Other relevant stakeholders from MQA, skills development service providers, and the DMRE

(NB: All participants were identified on the basis that they were knowledgeable in aspects related to mine health and safety and the related 'demand and supply of skills' required to deal with health and safety issues):

Table 1.4 A total of 34 respondents working for 20 companies were interviewed

MMS sub-sector representation	**Number of people interviewed**	**Number of Companies**
Coal Mining	4	2
Gold Mining	3	2
Platinum Group Metals (PGM) Mining	5	2
Diamond Mining	3	2
Other Mining	5	2
Cement, Lime, Aggregates and Sand (CLAS)	2	2
Services Incidental to Mining	8	4
Diamond Processing	2	2
Jewellery Manufacturing	2	2
Total	**34**	**20**

1.7 DATA ANALYSIS

The data that was gathered from both primary and secondary sources including focus groups and one on one interviews, was aggregated and analysed. Aggregated data was presented using tables and figures. The skills that were noted as essential to improving health and safety in the MMS, referred only to those critical skills that industry representatives had highlighted as having "high critical value" and were also ranked highly on our analysis scale.

Given that the data gathered was qualitative in nature and was primarily gathered through interviews, content analysis was employed for analysis of the data. Content analysis assisted in identifying the key concepts and themes contained in the data (Page & Meyer, 2000). Since the variables investigated were related to the demand, criticality, and shortages of the specific health and safety skills in the MMS sub-sectors, the review of the data using content analysis resulted in the identification of the categories of skills and occupations that the companies were particularly struggling with in acquiring to improve health and safety outcomes. The results of this analysis coupled with the literature review on the current qualifications related to the health and safety skills informed the recommendations of the study.

1.8 MMS SUB-SECTORS INCLUDED IN THE STUDY

The MMS sector involves a range of industries such as mining of minerals, processing of mined minerals, and export or domestic sales of raw or refined/manufactured mineral products. With respect to this project, the study boundary of the research will include all MMS sub sectors. MQA is responsible for administration of skills development in the following nine sub sectors:

- Coal Mining
- Gold Mining
- Platinum Group Metals (PGM) Mining
- Diamond Mining
- Other Mining
- Cement, Lime, Aggregates and Sand (CLAS)
- Services Incidental to Mining
- Diamond Processing
- Jewellery Manufacturing

Figure 1.6 MMS sub-sectors in pictures

MMS sub-sectors

The following paragraphs provide some background to the MMS sub-sectors to be analysed.

Gold mining

Commencing from the discovery of major gold deposits in the Witwatersrand Basin, the gold mining industry in South Africa played a substantial role as a foundational industry in the development of the overall South African industry. Since then, the goldrush attracted national and multinational cooperation sparking an economic boom with three of the world's largest ten largest gold mining companies having headquarters in South Africa. Until the year 2009, South Africa dominated the world as the number one gold producer. Today, the country's gold reserves are ranked first globally while the country's gold mining industry is seventh in production contributing 5.6% to global production.

Diamond mining

South Africa has the most diverse range of diamond deposits and these include open pit, alluvial, underground kimberlite, pipe, dyke and fissure mining. Majority of diamonds in the country are predominantly derived from several kimberlite clusters mainly located in the east of the country. In the year 2015, South Africa was ranked the seventh producer of diamonds in the world whilst the previous year saw local diamond sales that totalled R8.8 billion with foreign exports amounting to R7.73 billion.

CLAS (Cement, Lime, Aggregates and Sand)

Since there is no formalised definition of small-scale mining, it is often defined in terms of the mines output, capital investment, number of people employed as well as the managerial structure. In comparison to the larger mining companies, small scale mining is characterised by instability and many seasonal miners. To monitor this occurrence, legislation endorses equitable mining rights. The CLAS subsector falls within small scale mining and is closely linked to the construction sector. This sector is the smallest contributor to the mining industry and as of the year 2015, the CLAS group recorded a decrease of four percent (4%). The ease of access to these minerals means that no specialised skills are required for extraction resulting in low overall earnings.

Platinum Group Metals (PGM)

Platinum-group metals consist of a family of six similar elements which are divided according to their densities, into two main categories. The elements in the heavier category are comprised of platinum, iridium and osmium whilst the lighter elements category consists of palladium, rhodium and ruthenium. Due to their economic value and higher quantities, platinum and palladium are the most important PGM whilst the rest are mined as by-products. South Africa's platinum reserves rank first in both reserves and production as 87% constitutes the global reserve base whilst contributing 58.7% to global production.

Diamond Processing and Jewellery Manufacturing

The mining value chain results in opportunities for extraction, processing to shipping and beneficiation of minerals such as diamonds, zinc, lead, copper and manganese. Processing minerals locally has the potential of boosting the manufacturing industry whilst creating employment opportunities in the sector. South Africa's diamond manufacturing industry is currently dominated by 221 licensed diamond manufacturers with De Beers as the major supplier of rough diamonds to the sector.

Although the country produces 24% of the world's precious metals and stones, it only manufactures 0.5% of the world's jewellery. To date, Oro-Africa Pty. Ltd is the largest jewellery manufacturer, refining over 75% of the continent's gold. The rest of the manufacturing companies are small and employ as little as 10 people, most of which are in Gauteng, Western Cape and KwaZulu-Natal.

Services Incidental to Mining

The mining industry is not only dependent on specialists in the line of mining, but it also has a high intensity demand for specialists outside the vocation of the mining discipline.

The Services Incidental to Mining consists of professions that arise as a complementary to the effective functioning of the mining industry such as research and development, payroll services, manufacturing, distribution, transportation and logistics, consulting services, catering as well as training.

Coal Mining

The use of coal in South Africa dates back to the Iron Age, when charcoal was used to melt iron and copper, but large-scale coal production started in the 19th century. According to the Mineral Council of South Africa (2019),

- The coal industry employed 86,647 people in 2018 (82,248 in 2017), representing about 19% of total employment in the mining sector
- 253 million tonnes produced in 2018 (252Mt in 2017) with total coal sales of R146 billion (R130 billion in 2017)
- Since 2009, net investment in the coal industry has declined at a rate of 10% per year – from R7.3 billion to R3.8 billion in 2017
- The coal industry spent R61 billion procuring goods and services, most of it locally, thus contributing to the creation and maintaining of jobs in other industries
- 70% of coal volume is consumed domestically and more than 70% of electricity demand is generated from coal power

Other Mining

Mining commodities that fall within the ‘other mining’ category include minerals such as uranium, copper, chrome, iron-ore, manganese and salt. Since uranium is a by-product of gold mining, its production has been in decline in line with the lower gold production trends. The copper market is divided equally between domestic consumption and exports, copper substitutes include aluminium, titanium, steel and plastic. South Africa’s iron-ore reserves rank 13th in the world and has remained one of the most volatile sectors in the mining industry due to the massive reduction in global demand, particularly China.

Mining and Minerals Sector value chain to be considered in the study

Figure 6 illustrates the generic mining and minerals value chain that will be used as a reference throughout the study.

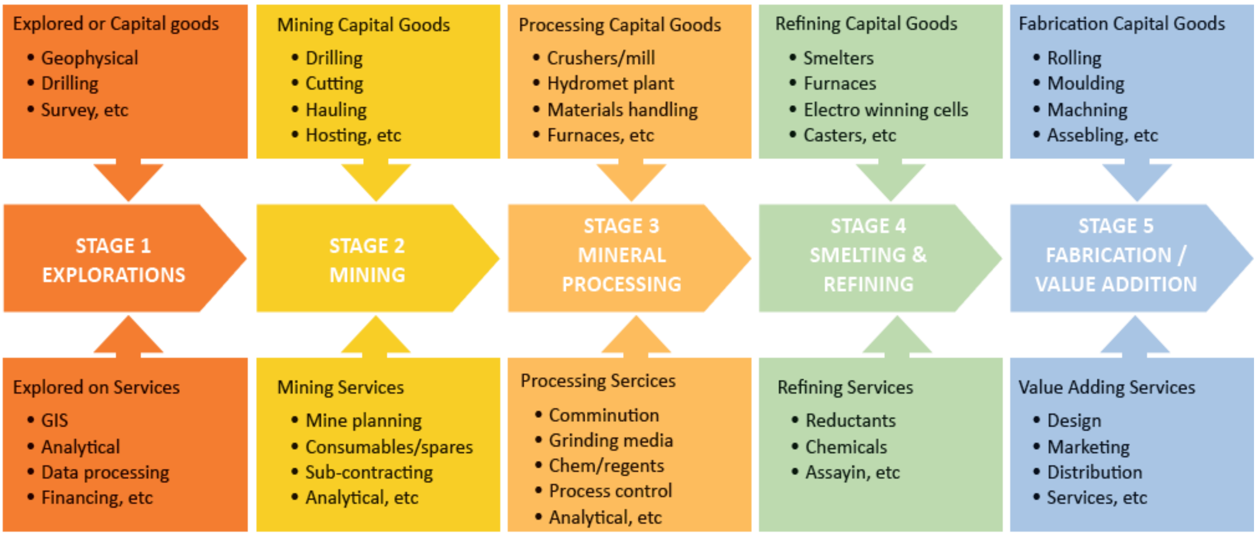


Figure 1.7 Mining and minerals sector value chain

(MQA, 2019)

The above value chain will be augmented with life cycle stages of generic mining activities to expand on the processes involved in the MMS. These include:

- Exploration
- Mine design and planning
- Construction/establishment
- Production
- Closure
- Reclamation and rehabilitation

Assumptions and limitations

The following assumptions and limitations applied to the study:

Project duration: The project was planned to be undertaken within three months. On closer analysis by the research team, this was deemed insufficient especially as the project timeline included the months of December and January where most mines close operations. The duration of the project was further hindered by ethics clearance processes which take over a month.

Data reliability: The success of the research in identifying the health and safety issues and the demand and supply of health and safety skills in the MMS was reliant on the accuracy and completeness of the data gathered throughout the study. This in turn means that the data and sources needed to conform to the highest research standards had to be valid, reliable, authentic, relevant, recent, and sufficient.

Despite the fact that the industry has prioritised the zero-harm aspiration, not much has been done to identify skills relating to health and safety matters in the industry. There was therefore, a need for primary data and expert analysis to ensure that the data collected could inform the development of appropriate recommendations

Company sampling: The focus was to ensure both size and geographic spread of various MMS sector companies.

Respondents: The focus was to ensure that the relevant representatives in health and safety, employees, managers, skills development facilitators and suppliers were interviewed. There was also a need to consider the question of gender as issues of health and safety might affect men and women differently.

This study examines issues related to mine health and safety all through the process of mining and processing that endanger the life of employees. The next section defines some of the concepts used in this study.

Definition of concepts

Fatalities: Fatalities were coded to identify job categories, activities, causal factors, and contributing factors for slip, trip, and fall fatalities at surface mining facilities. Labourer, equipment operator, machinery and or maintenance, with supervisor, management or trainer were job categories associated with a large proportion of fatalities within the mines (Nasarwanji, 2016).

Occupational accidents: In this study, occupational accidents would be defined following the conceptualisation by Yilmaz and Alp (2016). According to these authors, *“Occupational accidents refer to events that happen at workplace that cause disabilities, trauma, pain, and loss of life”.*

Occupational diseases: This refers to chronic illness caused by activities at work. An occupational disease is typically identified following its dominance in a given workforce than in the overall workforce, or in other worker populations (Rodriguez-Fernandez et al., 2016).

Occupational safety climate: According to Leitão and Greiner (2016), occupational safety climate refers to the perceived value attached to safety in a company over a given period of time. These perceptions and beliefs can be influenced by various factors including the attitudes, values, opinions and actions employees and managers; it also depends on time and circumstances.

Occupational safety culture: Occupational safety culture refers to workers’ beliefs, values, attitudes, norms, behaviours, and habits at work, and how the employees respond to changes to the occupational safety norms (Kim et al., 2016). Occupational safety culture is often described as the “personality” of a company, given that it is a collective value of safety (Zivkovic & Ivanova, 2016).

Occupational health: Occupational health may be defined as a condition that results from exposure in a workplace to a physical, chemical or biological agent to the extent that the health of the worker is impaired (Samantra et al., 2019).

Occupational safety and health (OSH): OSH refer to the safety, health, and welfare of people at work (Hermanus et al., 2015). It also captures the physical, emotional and mental land scope of the worker in close relation to their environment or workplace (Amposah-Tahwiah & Mensah, 2016).

Occupational safety and health risks: An occupational safety and health risk refers to occupational hazards accepted as a consequence of a particular occupation.

Occupational and safety risks often arise associated with industrial accident and environmental impact risks (Wu et al., 2016).

Occupational safety systems: Occupational safety systems is a pseudonym given to describe the company safety systems include training, audits, instructions and other safety measures that promote occupational safety and health (Line & Albrechtsen, 2016).

Risk management: In the nature of the mines it entails complex systems that ought to inculcate human interference within the ecosystems, linear destruction of infrastructure, gas emissions, land and water pollution (Domingues, Baptista & Diogo, 2017).

CHAPTER 2

REVIEW OF LITERATURE ON FACTORS CONTRIBUTING TO FATALITIES, INJURIES AND OCCUPATIONAL DISEASES IN THE MMS

We reviewed literature on fatalities, injuries and diseases in the MMS in order to understand their nature, primary and underlying causes and relate findings to competencies and skills needs in the MMS.

2.1 COMMON HAZARDS IN THE SOUTH AFRICAN MINING AND MINERALS SECTOR (MMS) CHEMICAL HAZARDS

There are many hazards arising from mining operations in the MMS (Utembe et al., 2015). In particular miners are exposed to chemical hazards. Many chemicals are used in mining operations in particular in laboratories. Explosives which are used to break the rock are made of chemical materials which if not properly managed cause illnesses as well as physical harm to the exposed workers. Jerie and Sibanda (2010) revealed that chemicals can enter the body through inhalation by breathing in dust, gas fumes or vapour through the mouth or nose. They can also enter the body by way of absorption through the skin. In underground mines where ventilation is inadequate, chemicals cause various health problems including lack of oxygen, skin and eye problems. When toxic chemicals like mercury enter the body, they cause long-term health effects for instance WHO revealed that exposure to elemental mercury vapours concentration of 27 mg/m3 may result in substantial mortality (WHO, 2003). A variety of respiratory effects are reported, including dyspnoea, lung oedema, necrosis of the alveolar epithelium, hyaline membranes, and occasional lung fibrosis (Armah et al., 2016).

Different studies conducted among miners confirm that they are exposed to chemicals from mercury, lead, cyanide and other gases associated with mining (Mutekede, 2014). For instance, a study conducted in Uganda reported that women who worked as salt miners suffered from genital corrosions and miscarriages due to prolonged standing in concentrated saltwater and exposure to silica and mercury poisoning (Hayes & Wagner, 2008).

2.1.1 Biological and psychosocial hazards

Mining is associated with poor working conditions, with the limbs of mineworkers exposed to biological hazards (Mutekede, 2014). Among the various dangers involved are the risks of snakebites and injuries. Bacteria, virus, fungi and blood borne pathogens also present significant health risks to mine workers (Abbasi, 2018).

Lehtinen and Joronen (2011) contend that psychosocial hazards are related to the way work is designed, organised and managed as well as the economic and social context of work. These hazards are also associated with psychological and physical injury or illnesses. The mining operations are associated with long working hours. Many workers travel long distances and may be away from homes for many days or even weeks. Loneliness and isolation can therefore be experienced. These situations cause anxiety in many workers and their families and many people are adversely affected in their personal lives. Violence in the mines arises from different situations including mobbing and bullying.

The workplace can be the most important source of health stresses if workplace operations have not been studied thoroughly and the associated health hazards have not been eliminated or controlled (Mutekede, 2014). According to the American Psychological Association (2017), the feeling of job insecurity, poor work life balance, poor remuneration and long working hours as well as unrealistic job expectations cause severe stress which may increase workers‟ vulnerability to other forms of health risks and workplace hazards. Prolonged stress can raise the risk for developing chronic and costly diseases for example heart diseases, diabetes and cancer. Stress can also lower the immune system and play a role in a person’s susceptibility to more colds, flu and other infectious diseases (Lu & Chen, 2015).

Drug and alcohol abuse have been a difficult issue to deal with in mining, but policies and procedures are now in place in most large mining operations (ILO, 2008). Debate continues about how to measure psychophysical impairment. Nevertheless, mining operations commonly require the measurement of urinary drug metabolites and breath or blood alcohol on pre-employment and following accidents (Buxton, 2013).

2.1.2 Mechanical hazards

Introduction of heavy earth moving machines such as dozers, loaders, dumpers and tippers, excavators, and shovels has increased the hazards of whole-body vibrations among operators. Long-term exposure to whole body vibrations is known to cause backache and other degenerative spinal disorders. Lu and Chen (2015) indicated that prolonged exposure to vibration lead to hand arm vibration syndrome a chronic and progressive disorder that affects the vascular, neurological and musculoskeletal system. The early stages of hand arm vibration syndrome are characterised by blanching of the fingers, tingling and loss of sensitivity when touching. This health effect can be debilitating, progressing to loss of effective hand function and necrosis of the fingers.

2.1.3 Physical hazards

2.1.3.1 Dust

The mining process involves drilling and breaking the rock or removing the soil (ILO, 1999). These activities generate a lot of dust and pebbles (Jerie & Sibanda, 2015). These dust and pebbles can be a nuisance and they can also be harmful to the worker’s body. According to WHO (2003), free crystalline silica is the most abundant compound in the earth’s crust and consequently is the most common airborne dust that miners face. Respirable particles are formed whenever silica-bearing rock is drilled, blasted and crushed into fine particles. Dust and pebbles can physically harm employees or may lead to physiological harm. Dust may get into the eyes of the workers involved if Personal Protective Equipment (PPEs) are ineffectively used (Phiri, 2011). Dust and rock particles may also interfere with vision and this increase the chances of accidents occurrences and it can also affect the skin causing all kinds of skin problems. Moreover, dust can also lead to occupational health problems if inhaled. Prolonged exposure to mining dust containing silica can result in silicosis which is a typical pneumoconiosis that develops insidiously after years of exposure. Exposure to silica is also associated with an increased risk of tuberculosis, lung cancer and some autoimmune diseases. NIMH (2011) evaluated medical records of 101 persons from stone mining area suffering from respiratory disorders and found that 73 workers had been suffering from silicosis/silico-tuberculosis, of which 16 had silicosis with progressive massive fibrosis.

2.1.3.2 Noise

Noise also presents a fairly common hazard in mining. The noise level in mining machine operations such as drilling, crushing, screening, blasting, etc. are far higher than the recommended occupational exposure levels for noise. Surveys conducted in South Africa by various institutions showed that noise exposure levels in most mining operations are higher than the recommended limit of 90 dB (A) (Love, 2015). A survey conducted in an underground mine showed that almost 75% of the mineworkers had evidence of noise induced hearing loss (Phiri, 2016). A recent survey by NIMH (2011) of 682 workers in opencast mines showed that 20-25% had evidence of noise induced hearing loss. Noise-induced hearing loss is mentioned as one of the most reported occupational diseases in mining in related scholarly articles from India, Iran, South Africa, Poland, Sweden, Chile, Canada, USA and Australia (Love, 2015).

Noise-induced hearing loss is a recognised problem in the South African mining industry, but the mines appear to have been more successful in complying with reducing noise levels than silica dust levels (Elgstrand & Vingard, 2013). Current data indicates that the coal, copper, iron ore and manganese mines are 100% compliant. Both the gold and diamond mining sectors in South Africa report that around 71% of their employees are exposed to noise levels (Van Kamp & Davies, 2013).

However, the proportion of over-exposed workers in the chromium and platinum mining sectors is almost 10-fold higher. In Sweden, the national statistics of reported occupational diseases (asking for compensation) included 24 cases among employees in the mining industry in 2010. Of these, 13 involved hearing problems caused by high noise levels. In Australian mining, 9% of injuries are caused by long-term exposure to noise, “an untenable statistic given the now long-established technical efficacy of the science and technology available for the prevention of industrial deafness (Elgstrand & Vingard, 2013).

2.1.3.3 Heat

Surface mining may be associated with solar heat or cold weather whereas underground mining is associated with hot temperatures most of the time (Elgstrand & Vingard, 2013). A study conducted in Zimbabwe reported that high temperatures and inadequate illumination negatively affects workers′ alertness leading to reduced concentration levels thereby increasing workers′ risk to severe occupational injuries (Ncube et al., 2015). Other sources of heat stress include the amount of physical activity workers are doing, the amount of air calculated, ambient air temperatures, humidity and the heat generated by mining equipment principally diesel powered (Stellman & McCann, 2018). These conditions take a heavy toll on the exposed worker’s body and they affect attention and concentration and thus increasing the risk of more accident occurrences. Elgstrand and Vingard (2013) argue that hot environments result in the worker’s body losing more water and salts leading to collapse. Heat stress can cause head stroke, cramps, exhaustion and rashes. Workers near hot surfaces are at risk of burns.

2.1.4 Manual handling (ergonomic) risk factors

Manual handling and physical ergonomic aspects of the work environment are identified as risk factors in the mines (Ncube et al., 2016). Different authors contended that repetitive motions, forceful exertions, vibration exposures, poor/awkward posture, forceful gripping and jolting/jarring are common risks in mining (Dlambulo & Motsie, 2014; Nzingana 2013; Mabika, 2018). Ngwana (2016) observed that a variety of common injuries could originate following irregular motions and prolonged postures of the workers body. Biomechanical overload and awkward postures are recognised as the cause of injuries amongst miners (Kim, 2018). These risk factors have also been identified in other studies conducted in the USA by (Abbasi, 2018), the Netherlands (Ariens et al., 2000) and South Africa (Dias & Schutte, 2015).

Ergonomic risk factors have been associated with the increased prevalence of occupational injuries and illnesses (Friedman et al., 2018). Some of these factors include time aspects of work. Predictable risk factors may include percentage of time with hands above the shoulders, working with hands above the shoulders, and working with trunk or neck flexion (Kim, 2017). Zwetsloot et al. (2017) analysed the impact of overtime and extended working hours on the risk of occupational injuries and found that working in jobs with overtime schedules was associated with 61% higher injury hazard rate compared to jobs without overtime.

The rise in longer shift hours is of specific interest because lengthy shifts are associated with behavioural impairments induced mainly by fatigue (Dozolme, 2017). Workers underestimate their fatigue and fatigue is linked with an enhanced danger of injury occurrences. Fatigue resulting from long working hours is associated with impaired response time vigilance/alertness (Ferguson et al., 2012). Incidents occurring during long working hours were more likely to result in a death or multiple workers injured. The study was confirmed in Zimbabwe by Chimamise et al. (2013); Friedman et al. (2018) who found that workers who worked more than eight hours per shift were more likely to get severely injured than those who worked eight or less hours per shift. However, studies show that long working hours have no impact on psychomotor functioning (Nakata et al., 2015). In addition, long shifts in manual labour are associated with lower job satisfaction, absenteeism and a decline in overall health (Friedman et al., 2018). The workers in mines are sometimes given set target for them forcing them to work more hours increasing the risk of injuries. Furthermore, change, lack of routine and being new at the mine were associated with injuries occurring 9+ hours into a shift among employees in the United States (US) mining industry between 1983 and 2015 (Kim, 2018).

Pelders and Nelson (2019) collected qualitative data at four gold mines and one platinum mine in South Africa and results showed that fatigue was attributed to extended working hours, harsh working conditions, high workloads, production pressure, and resource constraints, along with aspects relating to demographic and socioeconomic factors, living conditions, lifestyle, health, and wellness. Greater fatigue was significantly associated with younger age, indebtedness, a lack of exercise, poor nutrition, less sleep, increased alcohol use, poor self-reported health, more sick leave, higher stress, and lower job satisfaction.

Many underground mines have confined operator platforms (Zwetsloot et al., 2017), which result in miners maintaining awkward postures throughout their work shifts and thereby creating stress to their muscles and joints (US General Accounting Office, 2003). Most prolonged awkward body postures are as a result of restrictive ceiling heights and angles of the workplace (Dias & Schutte, 2005). McMillan and Nichols (2005) reported that a combination of lifting, kneeling and squatting, an activity performed by miners in the course of their work, is associated with a more excessive risk of injury than that attributed to kneeling and squatting alone. Repetitive work contributes the highest number of exposure reports amongst miners, followed by heavy lifting while constant use of vibration tools has the least number of reports (Torma-Krajewski et al., 2007).

2.2 THE NATURE OF FATALITIES, INJURIES AND OCCUPATIONAL DISEASES IN THE MMS AND MINES MOSTLY AFFECTED

Deep underground mines in South Africa are prone to seismic activity – making them some of the most dangerous in the world. Eight of the 10 deepest mines in the world are in South Africa. Increased depth of 5,000 m below surface in some cases, distance from the shaft, and drill time at the workface create health and safety challenges. Virgin rock temperatures can reach up to 60ºC at the depths mined. In addition, South Africa has been mined commercially for over a century and many operators still rely on older, labour-intensive mining methods such as hand drilling, while production pressures and profitability in the industry can lead to inadequate supervision and attention to safety (This is Gold, 2018; Senkhane, 2019).

Eighty-one mineworkers lost their lives in 2018 compared with the 90 fatalities in 2017, representing a 10% improvement in the number of fatalities year-on-year. The gold mining sector recorded no improvement in the number of fatalities year-on-year, reporting the same 40 mineworkers' fatalities in 2018 as in 2017. The Platinum Sector recorded the highest and most improved decrease in fatalities year-on-year with 12 fatalities in 2018 compared with 29 in 2017, constituting a 59% decrease. "Other mines sector" including diamonds, chrome, copper and iron ore was second to gold in the number of fatalities recorded: 20 in 2018 compared with 11 in 2017 constituting 82% increase (Kotze, 2019).

According to the Minerals Council South Africa, 35 fatalities were recorded by the mining industry in 2019 almost halving last year's statistic. The decline still emphasises the dangerous nature of mining operations in South Africa. The september fatalities statistics show that Platinum was the only sector reporting a sharp increase – almost two-fold in fatalities, from 8 in 2018 to 15 in September 2019, while the Gold sector fatalities decreased by 65% from 34 in 2018 to 12 in September 2019. Coal recorded an improvement of 50% decreasing from 6 fatalities in 2018 to 3 in September 2019. Fatalities reported by “Other mines” decreased three-fold from 15 in 2018 to 5 in September 2019 (Stoddard, 2019).

In the MMS, males are injured at more than three times the rate of females, likely explained by the high proportion of females employed in administrative tasks. Incidence of injury is higher for both the youngest, and the relatively older groups, with the incidence of injury increasing with age from year 20 onwards. Labourers involved in intermediate production, transport, tradespersons and related workers, are injured at substantially higher rates than workers performing other duties. Injury incidence differs by type of mining (Elgstrand & Vingard, 2013).

Most fatalities numbers in the South African MMS compare unfavourably with statistics in other countries. In South Africa, the fatality frequency rate (the ratio of deaths per million hours worked) fell from 0.3 in 2003 to 0.08 from 2014 to 2016 and rose again to 0.09 in 2017 but dropped back to 0.08 in 2018. According to the Minerals Council South Africa, the fatality frequency rate is currently 0.05 and higher than the 0.02 recorded by the mineral-rich Canadian province of Ontario in 2017 (which had no deaths in 2016), or the 0.01 reported by Australia in 2016. This narrowing trend can be attributed to the changing production profile of the SAMI, shifting to mechanisation in which mechanised equipment does a range of tasks such as drilling and bolting once done by workers in dangerous circumstances, exposing them to high risks (Stoddard, 2019). However, SA coal mines are safer than coal mines in the US as fatalities trend is consistently higher in the USA than in South Africa (Phakathi, 2018).

Over the past 15 years, the output of manganese, used to bolster the strength of steel, has quadrupled, while gold production is less than half of its 2004 levels. Iron ore and chrome production have also been climbing, with the latter more than doubling over the past decade-and-a-half. And these commodities are typically mined here in shallow, opencast operations which by their very nature are safer than the deep-level gold mines that dominated the industry for decades (Stoddard, 2019).

In Western Australia, the most recent fatal accidents in a 13-year review period were in the iron ore sector (i.e. surface), with one fatality underground. Changes in ground support standards and geotechnical knowledge leading to improved safety performance for underground mining; improved mine planning and stope scheduling in underground mines; use of remote loading techniques and raise-boring instead of rise-mining; ten-fold more workers in surface operations than underground, were all cited as the reasons for the improvement. With regard to commodity group, gold and nickel results together account for well over half the fatalities in the review period (Department of Mines and Petroleum, 2014).

The rate of work-related fatal injury in New Zealand remains higher than Australia and the United Kingdom. The United Kingdom has a robust and well-established health and safety system based on the Robens model, which is held as an exemplar of a 'world class' health and safety system. New Zealand and Australia and South Africa have followed this approach (WorkSafe New Zealand, 2017).

2.3 THE CAUSES OF FATALITIES AND INJURIES IN THE MMS

2.3.1 Primary causes of fatalities in the MMS

The critical hazards of the MMS include: explosives and fires (flammable gas explosions, coal dust explosions and fires); rock bursts due to seismicity and gravity; Rock falls (largest contributor to fatalities in the MMS); physical hazards (noise, vibration, temperature, illumination and radiation); machinery and transport (trackless, track bound and shafts and machinery such as conveyors, scrapers, fixed machines, tools and equipment) (Mine Health and Safety Council, 2014). These constitute the primary causes of fatalities in the MMS.

According to Phakathi (2018), the main contributors to mine disasters from 2015-2018 consisted of rock fall (21), rock burst (19), fires (10) and explosions (5). With regards to gravity and seismicity-induced fall of ground (FOG) fatalities, in 2017 there were 21 deaths attributed to gravity and 12 deaths as a result of seismic activity. Fire is the most commonly occurring hazard that contributes to high potential injuries (HPIs) in surface coal mines, followed by explosives, together representing 46 per cent of total incidents.

Most of the fires related to equipment. Seventy-two percent of explosive hazards were documented as misfires, which can be attributed to competency issues as well as the quality of explosive.

Anglo American reported that in 2016 seven deaths occurred in their platinum operations, two as a result of a fall of ground, four involved moving machinery and one occurred during an unplanned detonation of an explosive. At Kumba, an employee died in a moving-machinery incident and another was fatally injured while working with electricity. According to Anglo American (2016), several of the incidents arose as a result of front-line operational practice not being aligned with stringent safety policies. Anglo American identifies front-line supervision as a problem in their mining operations.

Falls of ground, transport and machinery are the primary causes of accidents resulting in fatalities and injuries in the MMS. Fall of ground (FOG) relates to the unexpected movement of the rock mass and the uncontrolled release of debris and rock as a result of gravity and/or pressure, strain burst and rock burst (This is Gold, 2018). MHSC and stakeholders have focused on addressing FOG accidents especially in deep-level mines and MHSC-led research outcomes have resulted in the implementation of new designs and methods that have in turn reduced fatalities and injuries associated with seismic activity from 48 in 2003 to 14 in 2017 (This is Gold, 2018).

Rock-related accidents remain a major concern in the MMS. Koldas (2001) conducted 25 rock-related accident investigations in a number of deep-level gold mines in South Africa and concluded that most accidents resulted from lack of support units in the working face area, poor mining practice, lack of hazard identification, poorly designed mining and support layouts and lack of strata control training for workers. The author suggested the implementation of a specific rock-related risk management in the MMS using a tripartite approach to deal with hanging wall hazards, support installations and seismic events.

Transportation accidents in the MMS are associated with trackless mobile machines, rail-bound equipment and collision with people in confined areas or close to moving equipment. Innovative vehicle avoidance systems have been introduced to mitigate risks and research is ongoing to find more efficient risk reduction systems. Underground fires cause smoke inhalation when ventilation infrastructure installed to clear smoke is unable to clear the area. Protection is afforded by providing workers self-contained self-rescue equipment and installing refuge bays, protected chambers located within 30 minutes of all working places equipped with fresh air, water and communication devices (This is Gold, 2018).

Similar primary causes of fatalities and injuries are reported in other countries. For example, a total of 202 fatal and nonfatal injury reports over a 10-year period in Ghana were analysed and the results showed that mining equipment was associated with 85% of all injuries and 90% of all fatalities, with mobile equipment, component/part, and hand tools being the leading equipment types. The most dangerous activities included maintenance, operating mobile equipment, and clean-up/clearing, while mechanics or repairmen, truck operators, and labourers were the most affected of the workforce (Stemn, 2018).

An International mining fatalities database report in Australia found that in underground coal mines the main root cause of death was due to fall in the roof or rib, once gas ignition explosions were discounted. One of the root causes of death was miners and other workers not always adhering to appropriate safe work procedures and entering unsupported ground. The majority of fatalities in open cut/surface operations were due to unintended operation of equipment involving brake failure, loss of control of equipment, failure to isolate adequately or unexpected re- energising of equipment (MacNeill, 2008).

Even with the technical advances in equipment and safety systems, incidents of a very similar nature to past events still seem to occur regularly in Australian mining. The main cause of fatalities in the non-coal mine operations is unintended operation of equipment, followed by contact with moving or rotating Plant (Guarding/Access to Danger Zone). In underground operations the main cause of death is fall of Roof/Sides/Highwall and accounts for approximately 34% of underground fatal incidents. Open cut mines are quite different in their main agent of fatality. The main cause of death in open cut operations is Unintended Operation of Equipment, which results in approximately 23% of fatalities (MacNeill, 2008).

2.3.2 Underlying or root causes of mine accidents

Analysis of accident investigation or fatalities reports reveal underlying or root causes of most mine accidents. A report by the Department of Mines and Petroleum (2014) examined and analysed 52 fatal mining accidents that occurred in Western Australia in a 13-year period from 2000 to 2012 to identify common hazards, causation factors and critical activities. Results showed that hazards associated with the work were known in most cases, with a procedure available to guide people in the task in 73 percent of fatal accidents. However, in 89 per cent of fatal accidents, there was either no procedure in place or the procedures or rules were not complied with.

It appears that the long-standing adage that there are “very few new accidents, just repeats of old accidents” is confirmed by these observations and illustrates the importance of a safety approach that is hazard and precaution based. This concept recognises that many accidents are repeat events where both the hazard and the precaution or controls that will prevent injuries are known (Department of Mines and Petroleum, 2014).

The fact that a relatively small number of accident types cause the majority of fatal accidents highlights the importance of principal hazard management plans. Principal hazard management plans consider high-level hazards at a mine, those that could result in multiple fatalities or repeated single-fatality scenarios. Accordingly, the authors of this report emphasised that improved supervision and strict discipline regarding procedural compliance can lead to rapid improvements in this area. Indeed, this could partly explain the marked improvement in accident outcomes at the end of the review period. Design of equipment underground and the behaviour of workers, or culture within the workplace were the main areas of concern highlighted by the researchers for review. A workplace which embraces a safe working culture is inherently a much safer place to work, and this should be adopted by all mines and regulatory agencies worldwide (MacNeill, 2008).

A recent root cause assessment study on fatalities from 2005 to 2015 in U.S mining shows a behavioural component to most fatalities among many other human-related root causes such as poor design and lack of technology and training (Burgess-Limerick, 2016 cited Willmer et al., 2015).

Aliabadi et al. (2019) analysed the severity of occupational injuries in mining in Iran and found that having taken a training programme related to workplace safety had the strongest influence on the severity of accidents. Workers' experience and type of accidents also had considerable effects on the severity of the mining accidents. Workers' marital status and the day of the week had the weakest effect on the severity of accidents.

In an earlier study, Aliabadi et al. (2018) analysed data relating to 305 mining accidents to identify critical deficiencies in organisational influences, unsafe supervision, preconditions for unsafe acts, and workers' unsafe acts. They found that organisational deficiencies were the main cause of accidents in the mining sector, as they affected all other aspects of system safety; an indication that organisational deficiencies should be modified first if work-related accidents must be prevented.

Regulations and laws are not enough to reduce the accidents and fatalities in the mines. Even though regulation carries a vital weight, it is essential to design out hazards by a systematic approach involving legislation, technology, training and education, psychological and motivational aspects, ergonomics, joint consultation between management and the workforce plus the will to enforce safety procedures (Eweje, 2019).

2.4 FATALITY IMPROVEMENT INTERVENTIONS

Research provides insight into stakeholder interventions such as the tripartite milestones to eliminate fatalities, injuries and occupational diseases resulting from mining operations in South Africa. Thus, Phakathi (2018) summarised the objectives of the 2024 Occupational Health and Safety Summit milestones agreed by stakeholders in 2014 that included:

Objective 1: Elimination of fatalities and injuries in the MMS. To attain this objective, milestones to be achieved include elimination fatalities by December 2020; all mining companies to target ZERO Fatalities; Achieve 20% reduction in Serious Injuries per year up to December 2016; From January 2017, reduce Lost Time Injuries per year by 20%.

Objective 2: Elimination of occupational lung diseases in the MMS. This objective is to be attained by achieving the following milestones: elimination of Silicosis by ensuring that 95% of all exposure measurement results are below the milestone level for respirable crystalline silica of 0.05 mg/m3 by December 2024; elimination of pneumoconiosis by ensuring that 95% of all exposure measurement results are below the milestone level for platinum dust respirable particulate of 1.5 mg/m3 by December 2024, and elimination of Coal Workers Pneumoconiosis by ensuring that 95% of all exposure measurement results are below the milestone level for coal dust respirable particulate of 1.5 mg/m3 (<5% crystalline silica) by December 2024.

Objective 3: Elimination of noise-induced hearing loss in the MMS. This objective is to be attained by achieving milestones at technical and individual levels: through the quietening of equipment so that by December 2024, the total operational or process noise emitted by any equipment must not exceed a milestone sound pressure level of 107 dB, and for the individual, that by December 2016, no employee's standard threshold shift (STS) will exceed 25 dB from the baseline when averaged at 2000, 3000 and 4000 Hz in one or both ears.

Fatality improvement interventions were undertaken by legislated MMS institutions. DMR issued two directives to eliminate fire, heat and oxygen deficiency related accidents and rock-bursts and rock fall related accidents coupled with inspections and audits to ensure implementation and compliance; 40 learners trained in rock engineering and seismology to address fall of ground incidents through collaboration of DMRE, MQA, MHSC, Council for Geosciences and South African Institute of Rock Engineers; holding Health and safety workshops to train and coach health and safety representatives and, the Minerals Council initiative CEO Zero Harm Forum was held to intensify scrutiny on the major causes of accidents and sharing of good practice (Kotze, 2019).

Stoddard (2019) also suggests reasons for this improvement include Government prioritisation of the safety of MMS workforce; introduction by industry of technological innovations in response to political, Trade Union and investor pressure; Workers being able to refuse entry into perceived unsafe area without threat of disciplinary action and, the declining size of the mining workforce. As a result of fatalities due to trucking and tramming, Lonmin (2017) reviewed trucking and tramming procedures and warning systems technology and installed beacons at strategic points to make drivers aware of oncoming locomotives as well as vehicle-to-vehicle detection systems in all locomotives.

With regards to changing behaviour through culture transformation, the MMS is improving accident investigation methods, modifying bonus systems to prioritise safety and implementing visible-felt leadership approaches that have been successful in yielding positive impacts in some companies (Phakathi, 2018).

2.5 PITFALLS OF MINING SAFETY

According to Senkhane (2019), OHS practice in the South African MMS is characterised by a number pitfalls: executives do not sufficiently emphasise on safety and operational risks that can lead to large-scale accidents; majority (78%) of executives agree that low incident rates do not correlate with reduced risk; inadequate engagement and empowerment of frontline organisation at mines, and little value is placed on asset reliability, supply chain integrity and process safety. Research has drawn focus to the empowerment of frontline supervision to improve safety in frontline operations where most incidents occur (Phakathi, 2010).

2.6 OCCUPATIONAL DISEASES AND FATALITIES FROM DISEASE IN THE MMS

There was an overall decline in occupational disease from 2004-2015: Pneumoconiosis, silicosis, NIHL, TB and HIV continue to be the key challenges. MHSC milestones are to eliminate pneumoconiosis, silicosis; noise induced hearing loss and to reduce TB and HIV/AIDS; targeting reduction in exposure by 95% by December 2024 (Minerals Council South Africa, 2017).

Occupational lung disease may result in illness, premature retirement because of disability, or death. There are significant costs involved, experienced by individuals in loss of income and medical or related expenses, and by mining companies through the loss of experienced employees and the expense of recruiting and training new employees, direct medical expenses and compensation levies (SIMRAC, 2001).

The mining sector reported major occupational diseases including noise-induced hearing loss (NIHL), Silicosis and pulmonary tuberculosis (TB), showing a decrease in cases by 3% from 4,632 in 2016 to 4,483 in 2017. Noise-induced hearing loss cases increased from 966 in 2016 to 1,141 in 2017, while reported silicosis cases increased from 635 in 2016 to 653 in 2018. TB cases decreased slightly from 2580 in 2016 to 2247 in 2017. The Masoyise iTB campaign by Government, Trade unions and industry increased screening and testing for TB and HIV among employees and community members and was effective in reducing the number of TB cases. There was an 8% increase in the reporting of medical health issues and improvement in medical deaths was reported in gold and coal commodities with a decrease in both sectors (15 deaths in gold sector and one in the coal) (Kotze, 2019).

Recent South African research has emphasised the need for new innovative and evidence-based approaches in the management of exposure to hazardous noise in the SAMI grounded on a holistic understanding of why current Hearing Conservation Programmes (HCPs) are not successful (Nomfundo & Moroe, 2018). According to the researcher, current HCPs and MHSC milestone targets focus only on hearing deterioration and the noise source without attention to the mineworkers themselves. Education of and buy-in from mineworkers with regard to mining conservation is a prerequisite for the success of interventions concerning mineworkers.

In Queensland, Australia, there was a major reduction in measured respirable dust levels in underground coal mines in the first half of 2017 compared to the same period in 2016, following regulatory changes that commenced in January 2017. These changes require coal mines to report respirable dust data to the Chief Inspector of Mines, and to report single sample exceedances of the occupational exposure limit. Hearing loss is an area of concern in Queensland mining, with 10 of the 19 permanent incapacities in surface coal mines in 2016–17 attributed to noise induced hearing loss (Department of Natural Resources and Mines, 2017).

2.7 SUMMARY OF FINDINGS, AND IMPLICATIONS FOR THE STUDY

The review found that mining operations in the MMS are characterised by the prevalence of hazards including chemicals, biological and psychosocial hazards; mechanical hazards from work equipment; physical hazards-coal and crystalline dust, noise, vibration, heat and various manual handling hazards. Mineworkers suffer from chronic diseases such as pneumoconiosis, silicosis; noise induced hearing loss, musculoskeletal disorders as a result of prolonged exposure to some of the hazards.

Deep South African underground mines are some of the deepest and most dangerous mines in the world. Though 35 fatalities recorded in the MMS in 2019 represented an improvement of about 50% compared to 2018, these deaths still emphasise the dangerous nature of mining operations.

By commodity, September 2019 fatalities statistics showed platinum as the only sector reporting a sharp two-fold increase, while the gold and coal sectors recorded improvements of 65% and 50% respectively, and “Other mines” improved three-fold compared to the previous year.

Explosives and fires, rock bursts, rock falls, physical hazards; and machinery and transport constitute the critical hazards of the MMS and the primary causes of accidents. Rock falls is the largest contributor to fatalities followed by rock burst, fires and explosions. Fire contributes the most to high potential injuries in surface coal mines, followed by explosives and together they represent 46% of total incidents.

Gravity and seismicity-induced fall of ground remains a major cause of fatalities in the MMS, while transportation accidents in the MMS are associated with trackless mobile machines, rail-bound equipment and collision with people in confined areas or close to moving equipment. Other countries report primary causes of fatalities and injuries in mining similar to those in the MMS in South Africa.

The review revealed that there are underlying or root causes inherent in the fatality accidents occurring in the MMS. In most fatal accidents, the hazards associated with the work were known in advance with a procedure to guide people in the task; there was either no procedure in place or the procedure or rules were not followed. There is thus a behavioural component to most fatal accidents among other human-related causes such as poor design and lack of technology and training.

Findings reveal that organisational deficiencies such as management influences, unsafe supervision, preconditions for unsafe acts, and workers' unsafe acts affect all other aspects of systems safety and as such are the underlying causes of accidents in the MMS. We suggest that these are important areas to focus competencies and skills training programme development.

The review found substantial efforts by stakeholders and individual mining companies to reduce fatality, injury and work-related illness rates in the MMS. The tripartite stakeholder milestones to eliminate fatalities, injuries and occupational diseases resulting from mining operations in the MMS form the nucleus of other interventions by legislated MMS institutions to reduce fatalities, injuries and diseases in the MMS.

The review identified two DMRE directives to eliminate fire, heat and oxygen deficiency related accidents and rock-bursts and rock fall-related accidents coupled with inspections and audits to ensure implementation and compliance; 40 learners trained in rock engineering and seismology to address fall of ground incidents through collaboration of DMRE, MQA, MHSC, Council for Geosciences and South African Institute of Rock Engineers; holding of Health and safety workshops to train and coach health and safety representatives and, the Minerals Council initiative CEO Zero Harm Forum was held to intensify scrutiny on the major causes of accidents and sharing of good practice.

Further, CEOs in the MMS lack sufficient focus on critical safety and operational risks that can lead to large-scale accidents while frontline organisation and supervisor engagement and empowerment were found inadequate.

With regard to occupational diseases and fatalities from disease in the MMS, reviewers determined that the MHSC milestones are to eliminate pneumoconiosis, silicosis; noise induced hearing loss and to reduce TB and HIV/AIDS, targeting 95% exposure reduction by December 2024, and that overall, cases of occupational diseases (NIHL, silicosis and TB) decreased by 3% in 20117 but persist as a concern for improvement to meet the zero harm milestone.

The review revealed that current hearing conservation milestones targets focus only on hearing deterioration and noise source without attention on mineworkers themselves. Education coupled with buy-in from mineworkers is a prerequisite for the success of interventions concerning mineworkers.

CHAPTER 3

REVIEW OF LITERATURE ON FACTORS INFLUENCING OCCUPATIONAL HEALTH AND SAFETY (OHS) PRACTICE IN THE MINING WORKPLACE

The research team reviewed literature on factors that impact on health and safety practices and performance outcomes to obtain greater in-depth understanding of OHS matters in the MMS in relation to skills development and OHS training. We researched the influence of the legal and institutional framework; emerging themes in OHS practice in mining; human and organisational factors influencing OHS practice in the MMS; production targets vs. Safety; person-machine interface and the impact of OHS training programmes on OHS practices and outcomes in the MMS.

3.1 THE INFLUENCE OF LEGAL AND INSTITUTIONAL FRAMEWORK

The South African regulatory framework comprises clear, concise and understandable legislation (MHSA, 1996 and Regulations thereof) stipulating enforceable minimum OHS standards; a well-resourced inspectorate to enforce compliance and protect mine workforce; data systems to capture, analyse and disseminate for use by mines OHS information; Leadership to lead the zero harm effort (Mine Health and Safety Council, 2014). The regulatory framework determines and shapes OHS practice in the MMS.

Ndegwa et al. (2014) investigated the legal framework as a determinant of implementation of occupational health and safety programmes in the manufacturing sector in Kenya and the results showed that there was a positive and significant relationship between legal framework and implementation of OSH programmes. The study concluded that improved legal framework in the form of legal requirements such as OSH Act, government inspections and audits and government support increased the implementation of OSH programmes which eventually led to reduction in work accidents, injuries and sicknesses, low insurance premiums and compensations and overall organisational productivity.

South Africa's health and safety legislative environment in the mining sector is guided by outcomes-based legislation that embodies general responsibilities for employers to provide safe and healthy workplaces, self-regulation, and participatory arrangements, allowing employers through engagement with workers to determine how particular outcomes are to be achieved. Outcomes-based legislation creates space for national health and safety strategy. The Mine Occupational Health and Safety Leading Practice Adoption System (MOSH) developed by the then Chamber of Mines and the now called Minerals Council South Africa and the tripartite 2013 health and safety milestones are an example of this.

The Mine Health and Safety Act (MHSA) 29 of 1996 is shaped by the approach to health and safety accredited to the British 'Robens Committee' or the Robens model whose main features are that employers have primary responsibility for risk management, and that workers are party to decisions about how best to address health and safety risks through elected health and safety representatives and structures such as employer-employee health and safety committees. All of these are features incorporated into the MHSA 1996 (Hermanus et al., 2015).

Similarly, the Queensland Mines Inspectorate has responsibility for administering state mining safety and health laws. In addition to its regulatory responsibilities, the Inspectorate also works with industry, unions and other stakeholders, to provide advice and assistance on safety and health matters, for the benefit of all workers. This tripartite approach is an important element in improving safety and health outcomes in the industry (Department of Natural Resources and Mines, 2017). In 2017 the Mines Inspectorate revised its organisational structure to create two distinct operating streams; Coal, and Mineral Mines and Quarries to better enable the delivery of responsive, targeted compliance programmes and initiatives, across the state.

3.2 EMERGING THEMES IN OHS PRACTICE IN MINING

In their 2012 Health and Safety Conference Report, the International Council of Mining and Metallurgy (ICMM) (2013) identified five emergent themes in mining OHS practice: Health and safety putting people first; leadership as the primary enabler of good health and safety performance; growing willingness for collaboration and learning through sharing experience, and the concept of integrated well-being guiding the development processes and the outcome of sound health and safety management, similar to the "integrated mining activities", one of the pillars of the Cultural Transformation Framework (Mine Health and Safety Council, 2014).

The priority goal of the mining industry is to prevent fatalities due to the fact that they persist despite devoted efforts to reduce injuries. Accordingly, people are at the heart of health and safety management, human life being more important than production. "Health and safety are first and foremost about the well-being of people: it is about building relationships with everyone at every level; it is about building trust; it is about enacting the belief that human life and well-being are more important than production or economic value" (ICMM, 2013; Mine Health and Safety Council, 2014).

The ICMM conference identified three fundamental shifts occurring in mining: movement from safety as a priority to safety as a value; from zero harm to zero fatalities and, from a culture of blame to one of care, ownership and accountability. As a value, safety should no longer be justified by making its business case. Values underpin all safety programmes and organisational culture making safety a privilege over production, extending beyond operations to contractors, families and communities.

Movement from zero harm to zero fatalities means that mining must incorporate fatalities from disease into the zero fatalities mind set. Mining operations involve hazardous agents that cause loss of life and therefore, rates of disease and health-related fatalities should be built into the concept of zero fatalities. In the MMS, the health of miners, in contrast to safety, has worsened, clearly illustrated by increasing rates of silicosis and tuberculosis and the Department of Mineral Resources and Energy's target to prevent silicosis will not be met unless concerted efforts are made to reduce silica dust to safe levels (Elgstrand & Vingard, 2013).

Health and safety considerations involve complex interrelated and integrated issues about people, processes and systems requiring integration at many levels, including between people and technical approaches. With regard to safety, behavioural reliability, operational integrity and leadership capability need to be integrated within the organisation, along with safety indicators. The management of the health component of

OHS is complex due to extended latency periods that exist between exposure and onset of disease. This can be addressed by integration with other health systems and community healthcare programmes (ICMM, 2013). In addition, management systems should integrate the use of leading and lagging indicators in the OHS management system.

For example, Ontario mining companies operate an integrated system called "Internal Responsibility System" (IRIS). The IRS has more recently been described as "a system, within an organisation, where everyone has direct responsibility for health and safety as an essential part of his or her job. It does not matter who or where the person is in the organisation – they achieve health and safety in a way that suits the kind of work they do. Each person takes initiative on health and safety issues and works to solve problems and make improvements. They do this both simply and cooperatively (Elgstrand & Vingard, 2013).

Lessons learned from a recent ERM Global Safety Survey (2018) across all economic sectors suggest nine emerging themes: (1) that stakeholders are becoming more concerned about safety and their expectations are rising; (2) that companies are increasing their investment on safety; (3) that significant safety cultural and performance challenges persist; (4) that risk is continuing to shift to contractors who are harder to manage; (5) that most companies do not understand how much they are spending on safety; (6) that lagging performance indicators remain dominant; (7) that established safety processes and programmes are not delivering sufficient impact on performance; (8) that harnessing data and technology to improve safety is a major focus and (9) that leadership engagement is key but leaders need to step up and gain new skills. We explain the views of the authors on these themes as they relate to OHS practice in mining.

3.2.1 Stakeholders are becoming more concerned about safety and their expectations are rising

Interviewees in the survey were almost unanimous that stakeholder expectations for improved safety performance will increase in all sectors and in all continents over the next 3 years. Stakeholders are becoming more concerned about safety and Regulators are taking an increasingly tougher stance in relation to safety performance. Leaders who are aware of the trend are engaging more on safety and driving action to improve safety culture and performance, focusing especially on fatalities and serious injuries. Increased stakeholder interest in safety also implies rising expectations in terms of performance and the challenge for companies is not just to ensure that their safety performance is improving but that it improves at a pace that is consistent with changes in expectations: double the challenge! For example, in South Africa, tripartite stakeholder cooperation ensured the adoption and implementation of the culture transformation framework (CTF) based on 11 pillars to promote OHS practice towards the achievement of zero harm milestones in the MMS (Mine Health and Safety Council, 2014).

3.2.2 Companies are increasing their investment

The survey found that companies have increased their efforts to enhance their safety culture and performance in recent years as a result of the increased pressure and scrutiny from stakeholders and the overwhelming majority of organisations surveyed are also planning to increase their investment over the next three years. Participants said the highest priority for investment was developing the capabilities of their people, followed by investment in improving management systems. The next highest priority was improving safety infrastructure/PPE and finally investment in software and technology. Thus, capabilities, leadership development and culture change are the top priorities and investment in these aspects is outpacing other areas by a significant margin.

3.2.3 Significant cultural and performance challenges persist

Despite organisations increasing their level of effort on safety and most of them reporting improved performance, the majority are dissatisfied with both their safety culture and performance. The occurrence of fatalities and serious injuries remains a crucial and persistent challenge for organisations raising important questions about the extent to which established safety processes and programmes and increased investment in safety can deliver the required outcomes. For example, research work in South Africa has raised the need to focus on the role of frontline supervision in improving safety culture in the MMS (Phakathi, 2010; 2017; 2018).

3.2.4 Risk continues to shift to contractors who are harder to manage

Globally, and across industry including mining, organisations rely more and more on contractors and the latter often perform more hazardous activities and are more challenging to manage. The study indicates that this trend will continue, implying further concentration of risk in the contractor workforce, a trend that is amplified by the fact that just over half of the study respondents believe their contractors are performing more hazardous activities. The majority of the respondents regarded contractor safety as more challenging than managing the safety of their own employees making a strong case for considering enhanced approaches to contractor safety. Other specific concerns on contractor management include cultural differences (contractor vs. Host Company), challenges in the procurement process (too little meaningful focus on safety and too much focus on cost) and a perceived need to maintain a hands-off approach with contractors (a focus on managing potential liability over risk). In some cases, companies erroneously believe that by training contractors they will diminish the liability attaching to contractors in the event of an accident.

The authors suggest that organisations can improve contractor safety through a better integration of safety considerations into every element of the contractor engagement lifecycle, especially in the early stages. This effort will require higher levels of engagement from procurement personnel and contract managers who will require up-skilling. Procurement personnel and contract managers’ focus on safety can have powerful impacts on performance over the whole of the lifecycle.

3.2.5 Most companies do not understand how much they are spending on safety

The survey found that safety training alone represents 1.5% of labour costs on average and this accounts for a very small proportion of companies’ total economic investment in safety. It is clear from these data, and respondents’ estimates of the amount they spend, that organisations are spending vast resources on safety. Organisations must have a better understanding of current and future costs associated with the development, implementation and execution of safety processes and programmes in order to obtain optimal value from their investment in safety.

3.2.6 Lagging performance indicators remain dominant

The researchers sought to understand how organisations are monitoring the efficacy of their established safety processes and programmes. Seventy percent of respondents referenced use of lagging indicators such as incident statistics. Only 26% of respondents use any form of leading indicators (15% use safety culture surveys or elements of their employee engagement surveys, 10% of respondents use audit processes for this purpose and 6% reported using cost/ benefit analysis techniques). Further, 25% of organisations do not measure the effectiveness of their safety training. The most popular method used by organisations who measure training effectiveness is the use of end-of-course evaluations. Only 20% of organisations are measuring the short or longer-term impact of training on culture, behaviours and safety outcomes.

These data indicate that few companies are using meaningful leading indicators to evaluate the efficacy of their safety processes and programmes, a rather surprising finding given the scale of companies' investments. There is a clear need for organisations to develop a more robust group of indicators that will provide them with deeper insight into the extent to which their established safety processes and programmes are delivering the intended outcomes. Indicators should provide accurate readings on the extent to which the processes are yielding the right culture, leadership and frontline behaviours and performance outcomes on the frontline.

3.2.7 Established safety processes and programmes are not delivering sufficient impact on performance

The authors of this survey also wanted to shed light on the extent to which established investments in safety are delivering value to companies. To this end, they analysed data from the respondents on their investments in safety, performance improvement, occurrence of fatalities, fatality prevention programmes (FPPs) and lifesaving rules (LSRs). They also asked respondents to consider their economic investment in safety processes and programmes and to estimate what percentage of this total effort is impacting culture and behaviours.

The results showed that changes in investments in safety over the past 3 years had no bearing on performance improvement. Surprisingly, the proportion of respondents who reported having one or more recent Safety injury and fatality was significantly higher for those who had implemented a fatality prevention programme versus those who had NOT. The Institute of Environmental Analytics (IEA) found NO statistical evidence in the data that implementing an FPP had any bearing on the number of years since the last safety injury and fatality.

With regards to OHS training, the researchers found that there is a positive correlation between hours of training provided and perceptions of safety culture. Investing in training seems to have a positive impact on culture. However, the IEA found statistical evidence in the data that the quality of training provided is a better predictor of perceived performance than the number of hours of training provided. Surprisingly, 40% of respondents believed their safety training does not change how their people think: NO impact on how people think implies NO impact on performance!

The researchers indicate that enormous value is trapped in established safety processes and programmes but there is an inherent conflict between the underlying purpose of safety processes and human performance. The underlying purpose of all safety processes such as permit to work, toolbox talks, and safety inductions is to ensure people are alert on the job, conscious of the hazards and using appropriate mitigations to address them. However, repetition inherent in the processes induces people to engage with them unconsciously.

Accordingly, the data present a clear and convincing body of evidence that the benefits derived from investments in established safety processes and programmes are not consistent with the scale of the investment in them. Established safety processes and programmes are not delivering sufficient impacts on leadership and frontline behaviours or performance. Hence, there is need to focus on the role of frontline supervision and new skills for them (Phakathi, 2018).

3.2.8 Harnessing data and technology to improve safety is becoming a major focus

The researchers sought to understand how organisations are harnessing data and technology to support safety. The overwhelming majority of respondents regarded harnessing data and technology as vital to improving safety performance and three quarters had a strategic priority to make better use of data and technology. As one of the pillars of the CTF in South African mining, a data system is required to ensure an effective and timely collection, capture, analysis, communication, dissemination and use by the MMS of mine health and safety information (Mine Health and Safety Council, 2014).

These findings were consistent across all sectors. There is a great deal of excitement about the potential for better use of data and technology – including wearables – to transform safety performance. Organisations are at different stages of maturity, with many organisations still evaluating the role that data and emerging technologies can play. Investment in data and technology is expected to become a higher investment priority over the next few years as organisations progress from the evaluate-to-implement stage in the investment cycle.

3.2.9 Leadership engagement is key, but leaders need to step up and gain new skills

Researchers also sought to understand if study participants believed senior, mid-level and frontline leaders in their organisations were sufficiently engaged in driving improvements in safety, and whether they had the necessary skills to positively impact their culture, behaviours and safety performance.

With regard to the most effective approaches to delivering behavioural change on the frontline, respondents overwhelmingly identified leaders' presence in the field as the most effective means of delivering behavioural change on the frontline, followed by communication/knowledge sharing and training and competence. These findings were corroborated by the IEA's analysis of the data that found positive correlations between respondents' perceptions of their safety culture and all aspects of leadership engagement tested in the survey. The IEA's analysis also found positive correlations between perceptions of safety culture and performance and all aspects of frontline leadership engagement tested in the survey.

The respondents believed there is a greater challenge of engagement with frontline leaders than with senior leaders, whereas senior, mid-level and frontline leadership engagement is key to improved safety culture and performance. Top-level commitment is not always making its way to the frontline. This was also corroborated by the 2010 study conducted (Phakathi, 2010). This means that leaders are not sufficiently present in the field and they aren't as effective as they could be when they are there. The emerging challenge is how companies can effectively engage leaders, whose immediate priorities are often focused elsewhere and who may not understand the direct and often long-term impact the decisions and actions they take have on safety culture, behaviours and performance.

The study calls for actions to better engage leaders at every level of the organisation on safety, to help them understand the role they do play in setting the culture and influencing the behaviours of their people in the office and on the frontline. It also suggests that leaders at all levels require up-skilling to ensure that their engagements are delivering much greater impact on their culture and performance.

3.3 HUMAN AND ORGANISATIONAL FACTORS INFLUENCING OHS PRACTICE IN THE MMS

3.3.1 Organisational culture

Organisational culture refers to the underlying approaches that shape how organisations manage OHS and means the system of shared values and beliefs about OHS that create behavioural norms for OHS which in turn guide OHS activities in an organisation (MHSC, 2010). Hence, a single organisation can have different OHS cultures across its locations and functions and recognising this plurality is important in controlling risks. For example, conflicts of interpretation and differences in priorities with regard to safety practices between the managerial and operational levels have been implicated in numerous industrial disasters. Unless such conflicts and differences are recognised and dealt with, cognitive dissonance can cause significant damage to risk control (Gherardi, Nicolini et al., 1998 cited Mine Health and Safety Council, 2010).

Organisational culture is critical to achieving high standards of OHS performance (Mine Health and Safety Council, 2014). Interventions to improve organisational culture should be based on the values and processes associated with exemplary performance. A strategy based on blame and seeking to avoid responsibility for organisational issues is unlikely to be successful while strategies solely directed to organisational issues neglect the essential contributions that individuals make to organisational life. A strategy that successfully integrates individual and organisational interventions is most likely to have the required results (Mine Health and Safety Council, 2010).

Stakeholders in the MMS have taken special interest in OHS culture following the adoption of the CTF and the zero harm milestones and agree that the values, attitudes and beliefs about OHS in this sector can constrain its capacity to improve health and safety performance.

A MHSC 2005 survey of the OHS culture in the SAMI found that the industry's OHS culture was significantly more negative than international comparisons (SAFEmap, 2005 cited Mine Health and Safety Council, 2010). A key difference was that the South African industry emphasised more on compliance with formal systems. The survey of 11 individual mines with a sample of 8991 found that the supervisory level reported more negatively than other categories of employees, likely to represent a major barrier to translating improvement strategies throughout sites. It also found "a high level of distrust between management and employees", also likely to be a significant constraint on the capacity of the industry to improve (Mine Health and Safety Council, 2010).

Research on OHS management in the MMS identified the organisational cultural features distinguishing workplaces with lower injury rates from poorer performers. These include: belief that OHS is an important issue in the workplace; openness to power-sharing criticism; work as a source of pride; employees' trust that management is committed to OHS; and employees' belief that they have some degree of control over the nature of their work (Hale & Hovden, 1998 cited Mine Health and Safety Council, 2010). Choudhry et al., 2007 cited Mine Health and Safety Council (2010) identified senior management commitment to safety, good communications, organisational learning, rewarding identifying safety issues and participative leadership style, as features of an effective organisational culture for OHS practice.

The Digging Deeper New South Wales (NSW) case study in Australia provided clear evidence of a link between organisational culture and effective OHS management. Results showed that good performers were differentiated from the bad by organisational features such as mindfulness, workgroup cohesion, and trust in management, organisational justice, and supervisor support and role clarity. Organisations that are characterised by these features also have a proactive approach to managing OHS (Shaw et al., 2007 cited Mine Health and Safety Council, 2010).

Organisational culture is critical to achieving high standards of OHS performance and interventions to improve organisational culture must be based on the values and processes known to be associated with exemplary performance. This implies that any strategy that is based on blame and avoidance of responsibility for organisational issues is unlikely to be successful. On the other hand, strategies that are solely directed to organisational issues neglect the essential contributions that individuals make to organisational life. Therefore, a strategy that successfully integrates individual and organisational interventions is most likely to have the required results (Mine Health and Safety Council, 2010).

According to Xingwana (2007), organisational culture plays an integral role in shaping the behaviours (e.g. productivity, absenteeism, and turnover) and attitudes (e.g. job satisfaction) of its employees. It is an integrated environment in which management plans, organises, leads, controls and creates a particular culture or the productive functioning of the organisation in pursuit of synergy between organisational and employees' objectives, organisational resources and extent influence, and alignment of employees' interests and organisational values.

3.3.2 Best practice examples: Safety culture

3.3.2.1 Codelco's leadership development programme for safety culture (Miguel Sanhueza: ICMM, 2013)

"A safety culture assessment in 2008 revealed a good management system but none of the other supporting requirements to develop the necessary safety culture: an overall score of 37 per cent was achieved. A leadership training programme was developed consisting of four courses in nine modules, requiring 36 hours for all managers and supervisors. An approach called the "leadership challenge process" was used. It moves through the concepts of "challenge, inspire, demonstrate, empower, encourage the heart". By 2011, the safety culture assessment recorded a score of 77 percent".

3.3.2.1 Gold Field's Cascade-geyser model (Juan Luis Kruger: ICMM, 2013)

Culture is important when dealing with people from diverse backgrounds, with different attitudes towards self, safety, community and even religion. These situations require extreme sensitivity. Gold Fields found that in merging two workforces, unskilled workers were higher risk. The company changed its focus first as to how it interacts with people: from being passive receivers of information to active participants in a conversation (which is defined as communication, participation and consultation). Gold Fields named this conversation model the cascade-geyser model – top-down and bottom-up.

3.3.3 Perceptions of management commitment

Evidence on OHS practice in the MMS suggests that commitment of management through all levels was is the source of the good performance in better performing mines: "The safety improved because you had committed managers, mine overseers and shift bosses that came to work to make a difference, to create a buy-in from the workplace, to put things in place. They did not force production if a situation was dangerous. They were willing to stand up and tell their higher-up reports that we did not blast here today because it was an unsafe environment, so that's it, sorry "(Mine Health and Safety Council, 2010).

3.3.4 Human and organisational factors influencing OHS practice in mining: international perspective

3.3.4.1 Organisational climate and safety climate

Workplace human and organisational factors include environmental, organisational job factors, human and individual characteristics that influence behaviour at work and support the critical controls put in place within the OHS management system and can therefore affect workplace health and safety. Common human and organisational factors include: fatigue and shift work; human factors in design; human failure; maintenance, inspection and testing; organisational culture; organisational change; safety-critical communication; staffing and workload and, training and competence (Willmer et al, 2015; Planning and Environment Resources Regulator, NSW Government, 2017).

Organisational factors are those that contribute to safety in the organisation itself: Safety Rewards, Safety Vision, Safety Learning, Safety Vigilance, Management Values, Communication, Training, Safety Systems, Physical Work Environment and High-Performance Safety Systems (Andrei et al., 2015). These researchers make a distinction between organisational factors and organisational climate. The latter refers to general dimensions of the work environment including leadership, roles, and communication and exerts a strong impact on individual motivation to achieve work outcomes.

While safety climate is a specific form of organisational climate describing individual perceptions of the value of safety in the workplace e.g. management values, management and organisational practices (adequacy of training, PPE provision, safety management systems quality), communication and employee involvement in workplace health and safety. Other studies show that organisational and safety climate factors predict safety-related outcomes including accidents and incidents (Neal et al., 2000).

Furthermore, the safety climate can have independent effects on individual knowledge, motivation, compliance, and participation-all important determinants of safety behaviours. Thus, if improvements in safety climate are to have any impact on safety performance, then they must first produce changes in employee knowledge or motivation. Interventions to improve safety performance should target both mediators. Interventions aimed solely at improving safety motivation (e.g. bonus and incentive schemes) are unlikely to be as effective as interventions that target both knowledge and motivation (Andrei et al., 2015). These researchers suggest that measurement systems to evaluate the effectiveness of safety management practices should incorporate assessments of knowledge, motivation, compliance, and participation to provide a more complete assessment, not only of the effectiveness of safety practices, but also of their operation.

According to these researchers, human and organisational factors impact on human reliability and performance, contributing to how effectively and safely a worker is able to do their job. How well these factors are managed will influence the likelihood of human failure.

Human failure refers to the error-making behaviour (e.g. mistakes and lapses) and violation behaviour (e.g. intentional rule-breaking) of individuals and both components of human failure are heavily influenced by the work environment, the organisation people work in, and the design of the job they are asked to do. When human and organisational factors are well managed, workers are more likely to do their job safely by not making errors or taking any violations. When they are poorly managed, or have not been considered, it increases the chances of human failure – worker performance reduces and incidents are more likely to happen (Willmer et al., 2015).

Numerous case studies and analyses of incident reports show that human error is influenced by human and organisational factors implicated as a cause of incidents in the major hazards sector. It is recognised that controls on human and organisational factors are now more important than technology because significant improvements have been made to ensure the increasingly inherent safety of machinery, technology and equipment. In addition, during accident investigation, operators more readily identify and improve on the physical issues than the underlying organisational factors. Advances in the control of human factors/organisational factors influencing error are less well developed, yet they are reported to account for 80-90% of organisational accidents (Reason, 1997 cited Bell & Healey, 2006).

Dragan et al. (2017) showed that the organisational factor is a determining factor increasing unfavourable conditions leading to “drift failure” by eroding safety margins in the entire organisation. Motivational biases mainly at the management level predominantly focus on performance and efficiency, neglecting safety adding to the complex systems' existing opacity and hidden connections between components and sub-systems that already create great potential of producing catastrophic events/accidents through initially small perturbations. These authors argued that the next level of safety performance will have to transition from coping solely with workplace dangers, to a more systemic model taking organisational risks in consideration. The researchers suggest that the organisation is in itself a new source of risk in the 21st century as many industrial accidents are traced back to organisational components including company's culture, safety culture, communication between groups, decision-making by people in authority, organisational clarity, etc.

3.3.4.2 Human and organisational performance as contributing factors to accidents

The Institute of Nuclear Power Operations (INPO) identified main attributes helping operators on nuclear generating stations to achieve the excellence in their integrated risk management and that are applicable in other industries (Dragan et al, 2017). The main attributes include: (1) Behaviours for an effective integrated risk management for four organisational levels (individuals, supervisors and managers, senior managers, and corporate executives) and additional behaviours for integrated risk management governance; and (2) Organisational characteristics for effective integrated risk management: these include principles, policies, oversight, and training established to ensure a comprehensive risk management strategy works throughout the life cycle of the nuclear plant.

3.3.4.3 Lessons from the Upper Big Branch (UBB) Mine Accident in the USA (source: Dragan et al., 2017)

"A massive coal dust explosion occurred at the Upper Big Branch Mine-South (UBB) on April 5, 2010 killing 29 miners and injuring two. This tragic explosion was the largest coal mine disaster in the United States in 40 years and reinforces the need for, and importance of, promoting a positive safety culture by routinely evaluating an organisation's safety culture activities and initiatives and by making enhancements and adjustments to ensure that an organisation remains proactive and appropriately focused on this important area".

The conditions that led to the explosion were the result of a series of basic safety violations and were entirely preventable. The root cause of this tragedy was deeply linked to violations of safety standards, unlawful policies and practices implemented by the owner, which resulted in the conditions that caused the explosion. This catastrophe clearly represents an ''organizational accident" (Dragan et al., 2017).

Key lessons learned included:

(1) Senior management dictates the tone for the balance between safety and corporate performance. These two items are not mutually exclusive and can and must successfully coexist. However, a strong safety culture demands a safety-first approach to business.

(2) No single event led to this catastrophe. Instead, it resulted from a series of events that were precipitated by a work environment in which workers were not encouraged to raise safety concerns and managers may have been discouraged from halting production in order to address an unsafe condition.

(3) This disaster may have been avoided had there been a more robust, positive safety culture in which workers and managers were encouraged to raise concerns.

Moving from a culture of blame to a culture of care entails evolving from the reactive top-down approach to a proactive ground-up approach which builds relationships based on trust out of genuine care for people. According to ICMM (2014), a values-based safety culture depends more on the quality of leadership interactions, including visibility and transparency, than on the quantity, although the latter is needed as well. Culture also cuts across all levels of the organisation: the safety culture in the corporate office manifests itself in the operations.

3.3.4.4 Employee perceptions and safety beliefs

Andrei et al. (2015) conducted a follow-up research to develop a more refined measurement of individual safety beliefs and enable an improved understanding of how safety beliefs influence safety related outcomes in the mining sector in South America as well as to identify areas to target training interventions. The researchers identified three main types of safety beliefs: Safety controllability (safety is something that people themselves can control and influence); internalised responsibility (people are themselves responsible for their safety and the safety of others) and, attitudes towards safety procedures and professionals (safety procedures/professionals negatively interfere with one's work). These types of beliefs were found to be associated with other individual factors influencing safety and they were also shown to add explanatory power for behaviours such as compliance and participation as well as to interact with organisational level variables in predicting safety behavioural outcomes.

South African researchers assessed the knowledge and practice of mineworkers regarding occupational health and safety regulations in their workplace and hypothesised that employees are not well informed on health and safety regulations, and that employers do not abide by the provisions of the health and safety regulations. The results showed that when employers are perceived to meet their obligations, treat employees fairly, and provide valued services and benefits, employees will reciprocate with higher levels of commitment and performance (Hlatywayo & Nel, 2013). In his concluding remarks at the 3rd Conference and Exhibition on Occupational Health and Safety in Mines in Istanbul, Dr Phakathi identified the need for the mining industry to focus on empowering frontline supervisors and employees and placing people at the centre of programmes to implement technology and innovation as key strategies to achieve the goal of zero harm (Phakathi, 2018).

The introduction of new technologies in mining reveals differences in perceptions. Open-ended interviews were conducted with senior managers and frontline workers in a Canadian hard rock mine following the introduction of a new set of safety principles to guide employee decision-making and behaviour. Results indicate that, relative to front-line workers, senior managers were significantly more aligned with principles dealing with injury prevention, management accountability, and rule following. Contrasts between front-line workers with above-average safety records and below-average records revealed only one significant difference: above-average workers were more strongly aligned with the principle "working safely is good business" than their below-average counterparts (Hine et al., 1999). A challenge at Petra Diamonds in South Africa relates to workforce safety maturity described as persistence of different levels of safety awareness and independence which leads to non-adherence to safety controls and breaches or policy and safe working procedures (Petra Diamonds Limited, 2015).

Mineworkers are continually being introduced to protective technologies on the job but their perceptions toward the technologies are often not addressed until they are actively trying to use them. This has the potential to halt safe technology adoption and associated work practices. A recent study by Haas (2018) explored management and worker perspectives toward three technologies to forecast adoption and behavioural intention on the job. Differences between workers and managers were revealed in terms of readiness, perceptions, and initial trust in using technologies. Workers, whether they had or had not used a particular technology, still had negative perceptions toward its use in the initial introduction and integration at their mine site, indicating a lengthy time period needed for full adoption. The key finding from these results is that a carefully considered and extended introduction of technology for workers in Stage 3 (undecided to act) is most important to promote progression to Stage 5 (decided to act) and to avoid Stage 4 (decided not to act). The author suggests that this model can help managers understand how to tailor messages about protective technologies, administer skill-based trainings and interventions that raise awareness and knowledge, and ultimately encourage safe adoption of associated work practices.

3.3.4.5 Practice evidence: Du Pont Safety Perception Survey (source: Du Pont, 2017)

The Du Pont safety perception survey (SPS) measures an organisation’s safety culture across three elements of safety management: Leadership, Process & Actions, and Structure and the results give organisations insights to help identify improvement opportunities and provide benchmark data to companies by industry. The survey enables organisations to uncover employee perception gaps across job roles, locations and divisions and helps them better understand the strength of their organisational culture across teams and demographics. It allows companies to benchmark their results against companies in their industry to track and improve safety performance (Du Pont, 2017).

3.3.4.6 Leadership and frontline supervision

Leadership is one of the 11 pillars of the CTF shaping OHS practice in the South African MMS (Mine Health and Safety Council, 2014). Leaders across all levels of the organisation have the capacity to influence others and contribute to OHS according to their level and competencies. For example, Tawiah et al. (2016) found that turnover intention of employees is heavily influenced by the commitment of safety leadership in ensuring the effective formulation of policies and supervision of occupational health and safety at work. However, some of the challenges to changing corporate culture in mining include the complexity of establishing ownership across an entire organisation from all workers up to CEO; difficulty of engaging supervisors adequately as they are many and serve as a filter and, the credibility of the safety message, notably how to get the values of the organisation into the different working modes at the front-line (ICMM, 2013; Phakathi, 2018).

In South Africa, criteria for selection into management roles often reward technical ability over other abilities. While outstanding technical ability is necessary, the ability to communicate, motivate and build an organisational culture that improves safety and productivity is far more important. Management behaviour is critically important in understanding the response of frontline supervisors and their charges to new management policies. Therefore, a well-structured supervisory training programme complemented by meaningful human relations and organisational changes is essential for improving productivity and safety in South African gold mines (Phakathi, 2018).
"I believe that the voice from the frontline is missing in boardroom discussions about organisational safety, production and people management. We can talk about zero harm every day, but if the voice of the worker at the rock-face is not heard, our discussions remain futile" (Phakathi, 2017).

According to him, Mineworkers use the term *Planisa* (to make a plan) to describe their strategies to exceed their targets and supplement their monthly incomes: "Planisa is not necessarily bad as it improvises both safety and production. It is a very innovative strategy (in most cases), but we need to eliminate the unsafe and unhealthy aspects of it" (Phakathi, 2017).

Phakathi (2010) identified the frontline supervisor as a change agent in the mining workplace and called for the introduction of forms frontline supervision that improve organisational performance particularly in the South African mining workplace where racial divides hampered effective development and implementation of supervisory training programmes. For example, at Petra Diamonds front line supervisors are responsible for achieving operational targets safely and their work needs consistency, detailed planning, preparation, enforcement of safety controls and support from management (Petra Diamonds Limited, 2015).

Frontline supervisors carry the heavy burden of ensuring safe operations. Research recognises that the stark reality of production pressures and the expressed intent to operate in a safe manner meet at the supervisory level, causing supervisors high levels of stress especially of messages are not aligned (ICMM, 2013; Phakathi, 2018). Senior leaders need to empower frontline supervisors by providing additional support in the form of skills development, work rationalisation and formal training programmes on specific issues, such as leadership, communication, relationships and emotional intelligence.

A survey of OHS leadership among business leaders in New Zealand found that more company boards are proactive or leading in their approach to health and safety with nearly all boards (93%) now getting OHS information at every board meeting. According to the survey results, CEOs are more involved in leading OHS in their organisations partly through site visits and personally recognising health and safety achievements. The survey revealed encouragement of reporting (93%), obtaining regular updates (89%) and supporting professional development (82%) as the main methods used by New Zealand businesses to develop OHS practice (Deloitte, 2017). Education and training was the first ranked OHS initiative being undertaken by businesses, followed in a descending order by reporting to capture and analyse data, culture change to get employees on board, including culture surveys, wellness checks and programmes for staff, hazard and risk analysis, prevention/education-new ways to do things, leadership, and communication (Caterpillar Safety Services, 2014).

3.3.4.7 Core leadership qualities

A literature review, interviews and focus group discussions enabled researchers to identify core safety leadership qualities: ability to instil respect and authority, lead by example, draw on knowledge and experience, preserve calm in a crisis, practice tough empathy, be sensitive to different cultures, recognise employee limitations, motivate and create a sense of community, place the safety of employees above everything and communicate and listen clearly (Arthur, D Little Limited, 2004). The interviews showed perceived gaps between desirable leadership qualities, and what is currently being exhibited suggesting areas of concern including clear two-way communication, tough empathy, openness to criticism, empathy towards different cultures, ability to create motivation and a sense of community, knowing employee limitations and being a team player.

The study findings formed the basis of a recommendation to introduce new skills training module in effective leadership and people management for Masters Officers across the entire maritime industry. The authors suggested that the modules be general in nature, not safety-specific, that training method be highly interactive and case-study driven and the topics should include: Personalising the leadership role, Communication, Understanding different cultures, Motivational skills, Understanding and empathising with your team, Team working, Dealing with conflicts, Coping with a crisis, Decision-making, Coaching, mentoring and appraisal, and Authority, discipline and blame (Arthur, D Little Limited, 2004).

3.3.4.8 Barriers to effective leadership

Barriers to effective safety leadership include resources and costs, industry structure and leadership, competence management (training emphasising more on technical skills than leadership abilities, cost constraints reduce the focus and length of training courses thereby limiting their quality and effectiveness); standards and implementation (Arthur, D Little Limited, 2004).

3.3.4.9 Influence of supervisors on actions to maintain OHS and the degree of their influence on the safety level

Martyk (2014) conducted a study on supervisors in coal mines in Poland and divided the individual competence of supervisors in a supervisory department in coal mines into the sub-categories higher, middle and lower level in order to ascertain the degree of influence each sub-category exerted on actions undertaken to maintain health and safety and the degree of influence on the safety level. The results of this study are important for understanding the role of the supervisory function at the frontline of mining operations and for designing skills development and training programmes for that level of leadership as shown in earlier South African research (Phakathi, 2010).

Competencies such as professional knowledge for proper execution of tasks, general knowledge of safety and safety management, and the ability to transfer knowledge and instruction to subordinate employees were found to have significant impact on safety level for all levels of supervisors. Higher and middle level supervisors should additionally possess analytical and conceptual skills (decision-making, problem solving, proper assessment of the situation) and organisational skills (efficiency, planning, division of labour, delegation, coordination), and good knowledge of safety rules, procedures and instructions. For the middle and lower level supervisors, essential professional skills (technical and other skills related to implementation) are essential.

The largest difference in responses on the effect of individual sub-categories of competence of supervisors to maintain a higher level of safety was recorded for Low-level supervisors including accountability, consistency and openness to change, while the smallest difference in responses was for the competency “the professional knowledge necessary for the proper execution of tasks”. Most supervisors thought this competency had a significant impact on safety level.

Deficiencies (gaps) in competence for the 3 levels of supervisors were determined using scales for knowledge, skills and motivation and personal traits. The author defined gaps as the knowledge and skills that are required by supervisors to be increased. Deficiencies in the competence of lower level supervisors consisted of general knowledge of safety and security management, knowledge and understanding of the documentation and changes in the documentation, the ability to transfer knowledge and instruction to subordinate employees, professional skills (technical and other related to execution of the tasks), analytical and conceptual skills. Deficiencies in competence of higher-level supervisors were revealed in the sub-category of interpersonal skills as well as one of the types of personality competence – readiness for changes. Shortages of skills and knowledge of transferring instructions, knowledge and understanding of the documentation and changes in documents were identified in the case of middle level supervisors.

From an employer's perspective, the perfect employee is not only one that is highly qualified and certified but should have adequate competence within his/her professional role. Thus, competence is more than just knowledge and skills; it is also associated with motivation, social skills, personality traits and emotional intelligence-features and abilities that determine the full use of the potential of the qualifications (Martyk, 2014).

According to this author, the impact of competence is marked on three levels: general knowledge in connection with expertise influencing the reduction or even elimination of errors in management and decisions; professional knowledge reducing errors in decision-task situations; and skills conditioning the lack of errors in regulations. The full potential of an individual is, however, determined by their ability to cooperate, communicate efficiently, judge fairly and make decisions, their empathy, assertiveness and resistance to stress, etc. Thus, the author suggests that the combination of high qualifications with desirable personality traits, social skills and motivation to use one's own abilities, results in professionalism, which entails the development of safe working conditions and safe operation.

3.4 PRODUCTION TARGETS VS. SAFETY

There is a strong focus on production in the SAMI characterised by high performance pressures and constraints to meet strict targets within specific timelines that may result in workers taking shortcuts thereby jeopardising safety at the mine (Masia & Pienaar, 2011). However, "health, safety and production are not competing objectives" (MHSC, 2010).

A Mine Health and Safety Council (2010) study found that in the MMS, site characteristics have an impact on the importance attached to OHS at work. Most sites were working towards achieving the goal of zero harm but sound risk management approaches to control risks at source were not in place and only a few sites directed initiatives to higher order controls, while most focused on lower order controls including disciplining employees, training and use of PPE. Most sites adopted a reactive approach to incidents rather than identifying, assessing and controlling risks before they cause harm. “Indeed, on site, while people spoke of the importance of OHS, we were often given examples of or even directly observed incidents that suggested that OHS was compromised in order to achieve production outcomes” (MHSC, 2010).

Safety is a primary motivator in respect of earnings as production bonuses at every level in the organisation are strongly influenced by safety performance (This is Gold, 2018). The basis for resistance to MOSH could be that leading practices have the potential to interfere with the pressure to meet production targets. Entry examination and making safe can and did result in longer periods of time spent securing the work area at the start of a shift (Hermanus et al., 2015).

Researchers found considerable confusion on mine sites about the existence of health and safety and production bonus schemes. Behaviours or outcomes rewarded by schemes were not identified and clearly specified. Schemes introduced negative effects such as staff being victimised for reporting an incident or injury that results in loss of bonus payments. The general manager on one site acknowledged that production bonus motivates employees to work hard daily but in return shifts workers’ behaviour away from safety: “If workers need to blast a face and there are not enough materials, they blast as much as they can and make a plan because of production bonus” (MHSC, 2010).

Bonus systems cause problems for middle management: “When doing dust sampling miners became very aggressive especially when they are to put on dust sampling equipment, because they think these procedures are a waste of their time and delay production and minimise their production bonus”, however, the absence of schemes were a source of frustration within poor OHS performers: “Incentives and bonus keep the spirit alive in every working place, without it no one gets motivated” (MHSC, 2010). Production and health and safety bonuses were less of an issue on better performing sites and one such site did not have one and at another the recognition the payment represented was deemed more important than the payment per se (MHSC, 2010).

Research materials have focused on the safety versus production tension driving increased pace of operations in mining and suggested a slower approach to tasks to remove employee distraction and ensure controls are in place; engagement with people at emotional level to promote buy-in and participation at all levels. This approach will deliver a prominent message namely, "we don't produce unless we can do it safely" (ICMM, 2013).

3.5 PERSON-MACHINE INTERFACE

In the mining industry machine-related accidents are prevalent; hence, NIOSH mining research studying human factors also examines the role of poor design of equipment, environment, process, or technology as a root cause of illness, injury, and fatality. Appropriate design accounts for human use and misuse of a system as well as human abilities and limitations. User-centeredness is incorporated into the concept/ideation level of products and processes by understanding the risks, functions, and the environment in which the tasks are performed and then applying the appropriate principles for safe-by-design (Willmer et al., 2015). The MHSA 1996 of South Africa makes specific reference to this in section 21(1)(c) "any person who designs, manufactures, erects or installs any article for use at a mine must ensure, as far as is reasonably practicable, that ergonomic principles are considered and implemented during design, manufacture, erection or installation.

3.6 OHS TRAINING PROGRAMMES AND THEIR IMPACT ON OHS PRACTICE IN THE MMS

Education and training are the foundations for enabling improvement in OSH. Jennings (2001) indicated a clear link between poor or inadequate education and training and poor OSH performance. Competency-based training facilitated the introduction of OSH competencies into various industry competency standards − a fresh approach to certification that is linked to career progression.

3.6.1 Training as a factor influencing OHS practice

Phakathi (2010) indicated that few organisations in the MMS have succeeded in empowering their production supervisors to initiate and implement change at work. He suggested that supervisory and management training programmes mostly fail to achieve leading OHS performance outcomes because of the tendency of top management to overlook human relations and organisational issues when transforming or introducing change in the workplace. In addition, such training programmes tend to undervalue informal learning and social organisation of work, focusing more on formal knowledge than informal knowledge derived from overseeing production and supervising people in the operation lines. Top management also fails to evaluate training programmes for their effectiveness in meeting organisational objectives. Literature on evaluation of OHS training programme effectiveness in the MMS is rather scant. A South African practice case study is in point.

3.6.2 Great Noligwa Mine supervisory training programme 2007 (source: Phakathi, 2010)

The researcher Dr Phakathi was a participant in the training programme for mine supervisors and wrote a test on the topics they had learned over three days: barriers to effective communication and steps in improving communication in the workplace, problem-solving, assertiveness, differences between what supervisors do and what leaders do, steps in improving leadership skills, steps in developing employees, characteristics of an effective coach and rules of coaching, creativity, managing diversity and managing performance in the workplace.

The researcher identified positive as well as negative aspects in the design and implementation of the course. The organisation was commended for recognising supervisors as change agents in the mine and the course was both informative and interactive. However, the planning of the course content was top-down as most discussions on operational issues reflected the perspectives of top managers and revealed a divergence between what supervisors were told and what really happened on the frontlines underground, especially the significance of the informal organisation of work through the gold miners’ underground practice of planisa. Work relations between supervisors and their superiors were to a large extent overlooked with important organisational issues such as materials and labour shortages and poor production coordination not mentioned. Underground work teams were not included in the training, hampering effective implementation of the materials learned. It did not make use of the subjective, day-to-day work experiences and practical knowledge of the shift-boss, stope team leaders and production crews.

In Australia, OHS education and training is provided through the trade unions, private providers, state technical and further education colleges and universities and in some jurisdictions basic OHS training is a statutory obligation depending on the circumstances. A National Mine Safety Framework was being developed to complement the Model OHS Legislation and will contain a nationally coordinated protocol on enforcement for mining inspectors (Elgstrand & Vingard, 2013).

A recent review of health and safety in Ontario recommended entry-level health and safety awareness training for all workers in every sector (more like the MQA training course for health and safety representative activities), training for supervisors, and broad changes to incentive programmes, enforcement, and health and safety education (Elgstrand & Vingard, 2013).

3.7 SUMMARY OF FINDINGS AND IMPLICATIONS FOR THE STUDY

The review revealed that the South African legislative and institutional framework is outcomes-based incorporating general responsibilities for employers to provide safe and healthy workplaces with self-regulation and participatory arrangements, thus creating space for national OHS strategy. This practice has been successful in countries such as UK, Australia, New Zealand, and Canada.

Recurrent paradigms were identified in OHS practice in mining that have a bearing on the competencies, skills and attitudes required for improving OHS performance in a constantly changing work environment. The mining industry is placing people at the heart of OHS management, recognising that human life is more important than production. Leadership is the primary enabler of good OHS performance and there is growing willingness to collaborate and learn through sharing experience, while the concept of integrated wellbeing guides the development processes and the outcome of sound OHS management. There is a shift in mining from safety as a priority to safety as a value; from zero harm to zero fatalities including deaths from disease, and from a culture of blame to one of care, ownership and accountability.

We identified nine emerging themes on OHS practice across all sectors and applicable to the MMS: (1) that stakeholders are becoming more concerned about safety and their expectations are rising; (2) that companies are increasing their investment on safety; (3) that significant safety cultural and performance challenges persist requiring new competencies and skills for frontline teams; (4) that risk is continuing to shift to contractors who are harder to manage requiring up-skilling; (5) that most companies do not understand how much they are spending on safety; (6) that lagging performance indicators remain dominant; (7) that established safety processes and programmes are not delivering sufficient impact on performance; (8) that harnessing data and technology to improve safety is a major focus and (9) that leadership engagement is key but leaders need to acquire new skills.

We examined the influence of organisational culture on OHS practices in the MMS and found that stakeholders in the MMS have taken special interest in OHS culture following the adoption of the CTF and the zero harm milestones and agree that the values, attitudes and beliefs about OHS in this sector can constrain its capacity to improve health and safety performance. We found that OHS culture in the MMS was significantly more negative than international comparisons, with the South African industry emphasising more on compliance with formal systems and not engaging sufficiently with the supervisory level and frontline teams.

Organisational culture plays an integral role in shaping the behaviours and attitudes of its employees. Senior management commitment to safety, good communications, organisational learning, rewarding identifying safety issues and participative leadership style, are features of an effective organisational culture for OHS practice. There is a clear link between organisational culture and effective OHS management. Good OHS performers are differentiated from the bad by organisational features such as mindfulness, workgroup cohesion, and trust in management, organisational justice, and supervisor support and role clarity. Workplaces that are characterised by these features also have a proactive approach to managing OHS.

The review found that organisational and safety climate factors predict safety-related outcomes including accidents and incidents. Safety climate can have independent effects on individual knowledge, motivation, compliance, and participation-all important determinants of safety behaviours. Thus, if improvements in safety climate are to have any impact on safety performance, then they must first produce changes in employee knowledge or motivation. Interventions to improve safety performance should target both mediators.

The review revealed examples of good practice based on an in-depth understanding of organisational cultural factors and safety culture, notably the Codelco leadership development training programme and Gold Field's Cascade-geyser model.

Employee beliefs were found to be associated with factors influencing safety in the mining workplace, adding explanatory power for behaviours such as compliance and participation. These beliefs interact with organisational level variables in predicting safety behavioural outcomes. When employers are perceived to meet their obligations, treat employees fairly, and provide valued services and benefits, employees will reciprocate with higher levels of commitment and performance in production and OHS. In the new mining landscape, mineworkers are being introduced to protective technologies on the job but their perceptions toward the technologies are often not addressed until they are actively trying to use them, raising the potential to halt safe technology adoption and associated work practices.

Thus, we opine that employee perceptions and beliefs are important influences in OHS performance and should be understood and considered in efforts to reduce fatalities, injuries and disease in the MMS. Interventions to improve safety performance should target employee knowledge, motivation and beliefs.

We found that leadership is one of the 11 pillars of the CTF shaping OHS practice in the South African MMS and leaders across all levels of the organisation have the capacity to influence others and contribute to OHS according to their level and competencies. Focus on the new mining landscape has enabled research to identify core leadership qualities to cope with the new realities. These could form the basis for new skills training programme for effective OHS leadership in the MMS.

The review revealed the frontline supervisor as a change agent in the mining workplace requiring new forms of frontline supervision capable of improving organisational performance. Research identified various supervisory competencies and skills that have significant impact on safety. These could form the basis of a well-structured training module for supervisors. The competencies should be associated with motivation, social skills, personality traits and emotional intelligence-features and abilities that determine the full use of the potential of the qualifications.

With regard to the impact of production bonuses and safety incentives on OHS performance, findings reveal considerable confusion in the MMS about them and lack of identification and clear specification of behaviours and outcomes awarded by the schemes. In poor OHS performing sites, workers take short cuts to meet production targets, compromising safety. Better performing sites either do not have bonuses or payments are rather symbolic.

The review found that education and training are the foundations that enable improvement in OHS performance, and that poor or inadequate education and training are clearly linked to poor OSH performance. Investing in training has a positive impact on safety culture though the quality of training provided is a better predictor of perceived performance than the number of hours of training provided.

CHAPTER 4

REVIEW OF LITERATURE ON FACTORS INFLUENCING RISK MANAGEMENT IN THE MMS

Literature on risk management in the MMS was reviewed in order to understand the factors influencing the process, including their relevance to skills development for OHS practice in the MMS.

4.1 UNDERSTANDING RISK MANAGEMENT AS AN ISSUE IN THE MMS

Risk management is at the heart of South African legislation and most modern health and safety regulations (Hermanus, 2007). According to Section 11 of the Mine Health and Safety Act, 1996 the manager must assess and respond to risks. We explored South African and international literature to understand factors influencing OHS practice in the new mining environment.

Mines focus on behaviour to explain incidents and as the main risk control measure. The transformation Framework expressed a shift in risk management in the SAMI from a focus on human factors to technology by seeking to eliminate risks at source coupled with investigating root causes of accidents and effective job safety analysis procedures. (This introduces a need to improve competence through skills training)

Every day, thousands of decisions are made at all levels of an organisation and some may relate to larger issues such as mine feasibility or mine design, while others may concern methods of work or accomplishing the task at hand. Many site decisions have the potential to result in significant undesirable risks. Hence, it is suggested that to address the need to improve, risk management should focus on improving the quality of decision-making (NSW Department of Industry and Investment, 2011).

Statistics from South Africa, Sweden, EU and other countries show that safety in mines has improved but also that mining is still dangerous compared to many other economic activities. However, as safety is improving, it is not enough to measure only lagging (after the fact) indicators, such as injuries and fatalities. Events leading to incidents must also be detected to prevent injuries from happening (Shooks et al., 2014; Stoddard, 2019; Kotze, 2019).

Companies can adhere to international and national health and safety laws and regulations as well as to international standards to improve and ensure a safe and healthy workplace, but some mining companies still do not comply with them. The risk management process is one way of dealing with this and consist of continuously identifying, eliminating or reducing risks in the early design phase and throughout the mining lifecycle (Shooks et al., 2014).

Human behaviour holds the key to further improvements in OSH and to the implementation of standards; therefore, greater effort will need to be directed towards promoting an understanding of risk assessment, risk management and safety audits that are specifically based on the behavioural contribution to accidents (Jennings, 2001). The purpose of introducing risk management is to improve health and safety, however, the challenge is how to introduce it in a well thought-out, structured way that is understood and practised by all, and is seen to be beneficial. According to Hermanus (2010), 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.

4.1.1 Requirements for effective risk management

Risk assessment is one part of an on-going process of risk management and assists the process by identifying the priority risks to be controlled and the options for controlling them; the risks that need careful and ongoing management and the nature of that management.

Risk assessment is only one component of risk management. Other components include: (1) the foundations of risk management such as understanding what could happen and how, real and visible commitment to managing the risks at all levels; (2) the structure of the risk management programme consisting of the physical facilities, equipment, management systems and procedures, people and how they are organised and work together, and emergency capability; (3) the actual management of risk entailing planning, organising, controlling, leading and motivating (NSW Department of Primary Industries, 1997). The requirements for effective risk management are described in Table 4.1.

Table 4.1 Requirements for effective risk management

Requirement	**Description**
Hazards: Potential for different types of accident	• Everyone understands the hazards and how accidents may arise • Understand how serious the accidents could be • Understand the preventive and protective measures
Appropriate facilities, machinery and equipment	• Must match the hazards
Appropriate systems and procedures	• Match the hazards, facilities, machinery and equipment: − System for operating to high standards (selecting, operating and maintaining equipment correctly) − System for monitoring performance (supervise and manage performance of machinery and people − System for advancing improvements − System for auditing and reviewing all systems
Appropriate organisation	• Provide appropriate staffing levels • Appropriate communication • Appropriate training
High level of emergency preparedness	• Provide means of early detection of onset of an emergency • Provide effective and prompt response
Committed management	• Management actively and visibly promotes safety and risk management

(Adapted from NSW Department of Primary Industries, 1997)

4.1.2 Approaches to risk management

Researchers of the 2010 MHSC baseline Culture Transformation project indicated:

"Risk management practices on mine sites were predominately reactive, with most activities associated with responding to incidents or seeking to control behaviour. The most common risk control measures related to procedures and protective gear; control at source was not a common focus of risk control efforts. For example, at one open cast site we were told that their strategy to control disc degeneration from whole body vibration was to provide nutritional supplements to truck drivers, rather than to seek to control the risks of vibration by providing improved seating and cab design" (MHSC, 2010).

Literature has suggested the need to shift from the value "zero harm" to "zero incident" as zero harm describes a reactive mind set in implying that an incident is expected to occur but that the consequences should result in zero harm. The Zero incidents principle describes a proactive mind-set and means that all risk management controls are appropriate and applied (De Jager, 2018).

Safety is a result of proactive risk management and is a concurrent activity to ensure that controls are in place before and during the execution of any task and not something that is done subsequently. For every task to be performed there should be an agreed safety procedure available and all staff should agree to work to it (De Jager, 2018). Findings from the MHSC survey showed that better performing mines treated risk management as an integral part of mine operations and took a more proactive approach, in one case incorporating risk control in mine development activities (MHSC, 2010). Further, the Australian Digging Deeper case study revealed that proactive sites were more prepared to do things differently with respondents indicating that they were encouraged to report bad news and identify areas for improvement (Mine Health and Safety Council, 2010).

A blame-seeking approach to incident investigation has been identified as a key precursor to major industrial disasters, such as the BP Texas City explosion in 2005. According to the Baker Review following the investigation, "employees and contractors must trust that they can report incidents, near misses, and other concerns – even when it reflects poorly on their own knowledge, skills, or conduct – without fear of punishment or repercussion "(Baker, Bowman et al., 2007 cited in Mine Health and Safety Council, 2010). Findings showed that such lack of trust was one of the key causes of the disaster that killed 15 people.

Blame is a strong feature of the South African mining industry: issues with blame were much more significant for those at the lower end of the organisational hierarchy but remained problematic throughout the organisational levels. Even where disciplinary action did not result from incident reporting, blame was perceived by employees through such actions as publicising the victim of an incident, e.g. placing photographs on notice boards or on intranets:

“The consequences that prevail from management after accident investigation make people not to report accidents. When there is an accident, the photos of subjects involved are taken and sent to all [corporate] sites stating that these people injured themselves and it makes it difficult for people to report accidents” (MHSC, 2010).

Errors and violations present an opportunity to identify potential risks in the operation of systems and environment. Thus, an approach to incident investigation that is satisfied with identifying who made an error is not useful in preventing recurrence and may even be counter-productive because it encourages non-reporting. Instead, incident investigations must treat human error not as a cause but a symptom and investigate the environmental and system causes that make error more likely.

Error-focussed approaches to incident investigation have the further problem that they result in blame on the person who made the error. This makes it more difficult for an incident investigation to gain all relevant information about the incident - open and honest communication is unlikely when the result of honesty might be disciplinary action. Consequently, the underlying causes are more likely to continue and, instead of preventing recurrence, the outcome might be even greater risk (NSW Minerals Council, 2004).

4.2 FACTORS INFLUENCING RISK MANAGEMENT IN THE MMS

4.2.1 Organisational culture

A challenge for risk management in the South African mining industry is dealing with risks that arise from natural causes such as seismic activity and methane explosions that cannot be eliminated. Action must be taken to reduce or control these risks at source. Research indicates that the ways in which such controls are developed and implemented including the organisational culture that determines their context can affect the effectiveness of the controls (MHSC, 2010). Organisational cultures of workplaces that control risks more effectively have features that enable them to anticipate adverse events and respond to them effectively after they occur. Such organisations are characterised as highly reliable as they are constantly alert to systems of failure by using strong hazard and error reporting systems, simplified systems that encourage diversity and difference to gather more views about a problem, paying close attention to operations to detect the early signs of potential disasters before they lose the capacity to prevent or control them (Weick & Sutcliffe, 2007 cited in MHSC, 2010).

4.2.2 Production and costs, bonuses and incentive schemes

Evidence from the South African MMS indicated that some mine sites focussed their risk management approach on the need for pre-start risk assessment, an essential aspect of sound risk control in mining. Data available from such assessments were not collated or analysed to inform more preventive risk control efforts. Researchers conducting the MHSC (2010) study found that one of the main differentiators of sites was the choices made when risk control measures had production or financial implications.

Production and cost were much more powerful drivers of actions on many sites: "The problem we have is roof support; our roof support is very poor and therefore poses a risk to the workers. Management tells us that there is no budget for roof support therefore the workers must blast that area so that the money that comes out of it can be used for roof support. "So we work in an unsafe area to make money so we can fix it" (MHSC, 2010). On such sites, interviewees reported that taking shortcuts was not only ignored, but actively reinforced by line managers. On one of the poorer performing sites, artisans reported that they often: by-pass the procedure to get the job done.

In his research on frontline mining teams, Phakathi (2010; 2018) found that production bonuses often encourage underground mine employees to hide accidents in order to meet their production targets and qualify for the bonus system. He argues that the manner in which the bonuses is designed is crucial to effective management of workplace health and safety at the point of production underground.

Goodrum and Gangwar (2010) used primary survey data from construction firms in the US to examine the impact of incentives on their safety performance and the results showed that incentives are effective in improving many of the safety indicators used in the industry. However, they also found differences within the industry regarding perceptions of their effectiveness. Workers had a more favourable opinion about the effectiveness of safety incentives than directors and managers overseeing the programmes. Workers' perception about the ability of incentives to reduce reportable incidents and change their safety behaviour was more positive than that of management.

Based on the findings, the researchers concluded that companies with a safety incentive programme have lower lost-time incidence rates and restricted rates than companies without; measured by differences in lost-time incidence rates, companies with a safety incentive programme experienced a greater improvement compared to the companies with no safety incentive programme; rewards that were based on team versus individual performance, injury versus behaviour performance and different time periods for giving the awards made no difference in programme effectiveness, whereas companies using only tangible awards had slightly better safety performance measures than companies that used both tangible and intangible awards; Workers had a more favourable opinion of the effectiveness of safety incentive programme than company managers and, while recognising that these programmes have some disadvantage, most workers felt there were no drawbacks and believe their greatest advantage is improving workplace safety.

The researchers posited that, though the results support the use of incentives to improve health and safety, such programmes cannot be successful on their own and must be part of a comprehensive workplace OHS programme that involves workforce training and engineers safety into the work process. The study identified the need to carry out research into the impact of incentives on worker behaviour during work process or operations.

The NSW Minerals Council in Australia acknowledged that any scheme which provided financial or other incentive to encourage people to work harder or faster might have the unintended consequence of supporting risk taking or short cutting safe work procedures (NSW Minerals Council, 2004). Equally, there is evidence that recognising and rewarding effective OHS management initiatives can have positive consequences. The NSW Minerals Council submission to the Wran Review in Australia pointed out that reward schemes can have the positive effect of “focussing behaviour to improve safe work practices”. The *Digging Deeper* study in NSW found that schemes which involved payment in exchange for achieving particular outcome targets did not consistently or reliably improve safety outcomes. There was some evidence of shortcuts being driven by high production bonuses and under-reporting of OHS injuries in an effort to gain payments and rewards (NSW Minerals Council, 2004).

It is commonly suggested that schemes are beneficial because they encourage effective injury management. However, industry stakeholders consulted in the *Digging Deeper* project identified that in a world class OHS system people contribute to OHS management, not because of extra money, but because it is ‘the right thing to do’.

Production bonuses and safety incentive payments can in fact undermine the achievement of a high performance OHS culture by rewarding negative behaviour such as taking short cuts and under-reporting of incidents. Incentive schemes that rewarded productive behaviour demonstrated more positive outcomes in the *Digging Deeper* project (NSW Minerals Council, 2004).

Literature has also explored the benefits of using economic incentives from sources outside the company such as tax reductions and insurance-related incentives to improve OHS performance at work. For example, The European Agency for Safety and Health at Work (2010) carried out a literature review and examined a number of cases which showed that external economic incentives can be effective in a wide variety of settings in order to promote OHS: in the German butchery sector notifiable accidents dropped by 25% in participating enterprises since they introduced the incentive scheme in 2001. 70% of the Polish enterprises that introduced a funded OSH scheme had fewer accidents and lower insurance premiums, and 50% reported fewer workers working in hazardous conditions. External incentives may be considered for small and some medium scale mining entities in the MMS which exhibit deficiencies in funding and expertise in OHS management.

4.2.3 Effective engagement as a factor influencing risk management

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 (Hermanus, 2007). Poor labour relations can disrupt the building of partnerships between managers and workers on health and safety. The author points out that 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 decisions.

Another barrier to effective engagement may be managers' concerns that participatory processes will undermine their control of operations. Yet evidence suggests otherwise. 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' (Hermanus, 2007).

Results of the MHSC (2010) study indicated that operational employees identified a difference between communication and involvement, expressing a desire to contribute to decision-making, not just passively receiving information: “We receive briefing from general manager on weekly basis about organisational performance. We are not involved in decision making about occupational health and policies”. Health and safety representatives across all performance categories expressed dissatisfaction with perceived exclusion from decision-making processes: “We are not included in decision making at all, the management is making all decisions for us and that creates problems”.

4.2.4 Incident reporting

Incident reporting is a critical support to effective risk management. The MHSC research found that most sites had formal reporting systems in place. However, many interviewees complained that action was not prompt in response to hazard reporting. They were expected to “make a plan” to cope with hazards they had reported instead of controlling them: “When you report an unsafe condition, they will tell you to make a plan”.

Health and safety representatives, as well as supervisors, have a key role in a reporting system. Unfortunately, the bonus payment systems were often cited as a constraint here: “Empower the supervisors and Health and Safety Reps – allow them to be free to report. If they see that something is not safe, allow them to stop work. Then we will have no problems. They still have a fear now, because they promised their manager a certain number of tons, of what will people say” (MHSC, 2010).

4.2.5 Supervision

Supervision is a fundamental safety function within all levels of an organisation. It complements the requirement to provide information, instruction and training, and influences how well organisations achieve the safety and health objectives of the MHSA, 1996. Effective supervision sets and maintains high standards of performance and the physical aspects of the work environment and is critical to achieving and maintaining the desired safety culture (Department of Mines and Petroleum, 2014).

The principal employer is also required to make key statutory appointments to establish clear safety accountability. These appointments cover the daily control and supervision of the mine and are accountable for ensuring that regulatory requirements and the principal employer’s policies and procedures are followed.

4.2.6 Management’s role

Management support for frontline supervisors is critical in risk management. Management should ensure that people with supervisory responsibilities know what is expected of them, including understanding and acting in accordance with legislative requirements, policy and safety performance indicators, organisational and task-specific procedures and requirements, the risks identified in the risk register, their area of responsibility, management of contractors, identifying and rectifying gaps in the knowledge and skills of supervisors, including understanding the specific hazards of their work processes, improving supervisory skills such as leadership, communication, managing people and managing resources (Eiter et al., 2016).

4.3 THE RISK MANAGEMENT PROCESS

Literature construes the risk management process as the continuous process of controlling risks and consists of specific steps: establishing the context and scope of the assessment process; Identifying the hazard; analysing the risk; treating the risk; communication and consultation; monitoring and review of controls (Shooks et al., 2014). 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 (Hermanus, 2010).

4.3.1 Context and scope

Establishing the context involves determining and agreeing on the risk assessment objectives and the risk criteria, the latter often defined by the organisation and specified in their risk matrix. In order to managing risks, the external and internal parameters must be taken into account. External parameters are social, regulatory, legislative, culture and competitiveness while internal parameters include the structure, roles and capabilities. The next stage is to define the level for which the safety analysis process will be applied (Shooks et al., 2014).

According to these researchers, it is seldom possible in the design phase to define the level to apply safety analysis as it is difficult to know exactly how the tasks will be carried out. However, it is possible to know the job and its subsequent tasks in broader terms, such as the operating of a machine. The smaller the boundaries and the more details and knowledge there is about the system, process or tasks, the more detailed the hazard identification will be.

4.3.2 Hazard Identification

This step is aimed at identifying the hazards: all situations in the workplace that have the potential to cause damage or injury to a person, the environmental, property or equipment. This is an important step in the risk management process as hazards that are not identified cannot be treated.

The use of safety analysis tools is good for a systematic process of identifying hazards. Some other ways of identifying hazards are through accident or incidents reports, statistics and workplace inspection. These are all methods that can be used in already established mines with a workplace history (Hermanus, 2010).

4.3.3 Risk analysis

Risk analysis provides a measure of the risk, making it apparent if the risk must be reduced or if it is at an acceptable level. It also helps focus the attention on managing the significant risks with high likelihood of occurrence and large potential impact. Risks can be evaluated using approaches for evaluating risk, such as comparing systems, relevance judgment and risk matrices – the latter widely applied in many areas. Risk matrices are regarded as easy-to-use and useful and constitute the predominant approach in technical publications (Harms-Ringdahl, 2013 cited Shooks et al., 2014).

4.3.3.1 Risk matrices

Risk matrices are presented as tables with consequences as one variable and probability as the other. For each identified hazard, the probability of it occurring and the consequence becomes the level of risk for that hazard. A simple risk assessment matrix adopted from Harms-Ringdahl (2013) cited Shooks et al. (2014) is shown in Figure 4.1. Some advanced risk assessment matrices include and define the consequence on people, assets and the environment. The authors pointed out that Even though risk matrices are widely accepted and used, little research has been carried out into validating the performance of risk assessment matrices in improving risk management decision despite their wide acceptance and use.

Probability	Consequence			
	Minor	Medium	Large	Catastrophic
Frequent	*Medium*	*Medium high*	*High risk*	*High risk*
Probable	*Medium*	*Medium*	*Medium high*	*High risk*
Remote	*Low risk*	*Medium*	*Medium*	*Medium high*
Very unlikely	*Low risk*	*Low risk*	*Medium*	*Medium*

Figure 4.1 Risk matrix with risk ranking

(Harms-Ringdahl, 2013 cited Shooks et al., 2014)

4.3.3.2 Risk matrix procedure

The risk matrix is generally considered a simple tool. However, for its results to be consistent and comparable, considerations must be taken on how it is executed. This procedure highlights the importance of clearly defining the rules; it takes away personal perceptions and assumptions from the risk assessment process. For example, probabilities should be defined as a number, e.g. how many times per year something happens. It is also important to define in what state the consequences and probabilities should be considered. This means defining if we are looking at the probabilities of something happening with current controls in place, or with no controls in place. This decision greatly alters the probability of something happening.

4.3.4 Risk treatment: The hierarchy of controls

The hierarchy of control can be visualised in several different ways (e.g. an upside-down triangle). We have chosen to use a more detailed model with three levels of risk control. The top priority in risk management is to eliminate the risks as far as reasonably possible. The first level is the most effective measure of control. It involves eliminating the hazard and associated risk. An example of this would be eliminating the risk of fall by performing the work at ground level.

If the first level is not *reasonable practicable*, risks should be minimised by substituting the hazard with something safer (e.g. replacing solvent-based paints with water-based ones); isolating the hazard from people, i.e. physically separating people from the source of harm by distance or barriers (e.g. installing guard rails around exposed holes in the floor); or using engineering control (e.g. using trolleys to move heavy loads, or setting work rates to reduce fatigue).

The third and last level should only be used as a last resort. It involves the use administrative control, i.e. work methods or procedures that are designed to minimise the exposure to a hazard. Examples of this include the use of warning signs, worker training, or the development of procedures for safe machine operation. The other approach is the use of personal protective equipment (PPE) (e.g. hard hats, gloves and protective eyewear). It is important to note, however, that PPE limits the harmful effects of hazard but only if they are worn and used correctly.

In an assessment conducted by the European Commission (2011), the costs and benefits of prevention measures was compared. The highest benefit cost ratio was found for measures aimed at substitution or avoidance. The lowest values were found for measures such as training and personal protective equipment. This study shows that measures considered as being the most effective, such as substitution and avoidance, are also more cost-effective (profitable).

4.3.5 Communication and consultation

Communicating and consulting is an essential part of risk management. Communication is the sharing of information and viewpoints; it is multidirectional, interactive, respectful and engaging. Consultation ensures that all relevant viewpoints are taken into account. By involving the right people at the right time, making sure they understand, are involved and contribute to the process, the best outcome of the risk management process will be achieved. This point was hammered home by the South African researcher, Phakathi (2010) the failure of management to consult frontline supervisors in planning safety training for supervisors. WorkSafe Victoria (2007) visualises the steps in controlling OHS hazards and risks not only as a continuous process of risk management but also emphasises the importance of consultation with health and safety representatives, employees and others, in controlling occupational, health and safety hazards and risks in all steps as required by law in Australia. The MQA developed and promoted the delivery of the Health and Safety Representative Qualification programme in order to promote consultation and improve OHS performance in the MMS.

4.3.6 Monitor and review

In South Africa, the Mine Health and Safety Act (MHSA), 29 of 1996, as amended, provides for the monitoring of conditions that will promote a culture of OH&S in the mining industry and protect mineworkers and other persons at mines (Hermanus, 2010). The risk management process is an on-going and constantly improving process. Workplaces and work tasks change over time; therefore the safety analysis process has to be carried out continuously to identify any new hazards. Furthermore, the process has to be revisited to ensure that no hazards were overlooked and that the controls put in place are effective. A hazard register which records and review hazards in the organisation must be kept. It is a summarised record of the hazards identified in a business indicating where the hazards occur, and the tasks, machinery or situations with which they are associated (WorkSafe Victoria, 2007; Hermanus, 2010; Shooks et al., 2014).

4.3.7 Safety analysis

In a project, safety analysis can be applied at all stages of engineering and is often applied many times with different levels of detail to provide required information for each stage. Safety analysis can be used in the feasibility stage, to decide whether to proceed with a design or not. When there are several options available, safety analysis can assist in choosing the safest one. During the execution and construction phase, safety analysis can help ensure that system risks are tolerable. In the operation stage, safety analysis can provide information if work tasks are conducted within an acceptable risk. This information can be used to create safe work instructions. There are a variety of safety analysis tools that are used dependent on the purpose or situation. These include preliminary hazard analysis (PHA), checklists, hazard and operability study (HAZOP), failure modes and effect analysis (FMEA), and fault tree analysis (FTA). Many organisations already have a documented risk management process including defined safety analysis tools (Shooks et al., 2014).

4.4 BEST PRACTICE IN RISK MANAGEMENT IN MINING

4.4.1 Case study on risk management (source: Eiter, 2014)

Fatigue has an impact on job performance of haul truck operators but also on the health of the operator and productivity, as well as beyond the mine site to the health and well-being of the surrounding community (Eiter, 2014). The author studied a small surface mining organisation in the US in order to highlight the fatigue risk management system implemented at the mine site. Mine safety personnel interviewed discussed the changes made to the infrastructure of the mine, to administrative areas such as the number of shifts and the use of vacation time, as well as the implementation of new technology into haulage vehicles as a fatigue risk management intervention.

The implementation of this fatigue risk management system was costly since changing the work schedule limited the total number of hours worked per week and reduced the amount of product moved from the site. This meant that employees may work fewer hours per week, but in the long run, employee quality of work/home life likely improved. Further, haul roads were widened and required an initial investment, as did the installation of rear vision cameras on the fleet of vehicles. However, this investment is small relative to the cost of the loss of a life and the penalties associated with that loss. In fact, investing in these changes can lead to long-term savings because of a reduction in property damage and lower insurance payments.

The mine safety personnel interviewed stressed the importance of implementing a fatigue risk management system that took into account mine-specific issues. Targeted changes can be made at a mine to increase the health, safety and happiness of the employees, but mine management needs to be in touch with the workforce to effectively implement and recognise the changes' value.

According to the US Mine Safety and Health Administration (MSHA) (2015), 37 mine workers were fatally injured in accidents in the U.S at metal and non-metal mine sites between October 2013 and January 2015, following a record low of 16 in 2012 and in 2011. In January 2015, Joseph A. Main, Assistant Secretary of Labour for Mine Safety and Health wrote to stakeholders in the metal and non-metal mining community and identified several areas where improvement was necessary to promote the health and safety of mine workers. One area identified was an increased focus on “daily and effective workplace exams (inspections) to find and fix hazards” (MSHA, 2015b cited Eiter et al., 2016).

4.4.2 Risk Management practice guide

The NSW Mine Safety Operations has published practice guides on the issue of risk management in mining. These include the Risk Management Pocket Guide and the General Workplace Inspection Checklist. The Risk Management Pocket Guide provides a daily prompt for people on the job to develop their understanding and experience by encouraging the daily discipline of managing risks whilst carrying out tasks in the mining and quarrying industries (NSW Government Industry & Investment, 2009).

4.5 RISK RECOGNITION AND RISK PERCEPTION AMONG MINEWORKERS: FACTORS AFFECTING THEIR ABILITY TO RECOGNISE HAZARDS

Hazard detection is challenging in the mining industry, despite the existence of regulation. Mining is a major undertaking involving the use of complex heavy machinery, equipment and processes as well as numerous and diverse worker activities that take place in a dynamic, challenging environment (Scharf et al., 2001).

Hazard recognition is integral to risk perception, situational awareness, and decision-making. If a mineworker is unable to recognise hazards, then he or she cannot take steps to eliminate or mitigate them. NIOSH has completed much research to provide insight into hazard recognition and mitigation to reduce injuries at mines (Willmer et al., 2015).

The health and safety of workers depend on their deciding whether to remove hazards and mitigate risks and how to do so. This makes it critical that miners are able to recognise site hazards and accurately assess their risks. Hazard recognition is the realisation that a condition or behaviour can cause harm and it is a necessary skill for all mine workers (Bahn, 2013 cited Eiter et al., 2016). However, an understanding of what constitutes risk is also a critical element. A miner must be able to identify a hazard and then recognise the risk associated with the hazard in order to make a decision on how to mitigate the risk and perform the task safely.

Risk perception is defined in literature as an individual's assessment of how risky a situation is in terms of the probabilistic estimates of the degree of situational uncertainty, how controlled that uncertainty is, and confidence in those estimates (Eiter et al., 2016). Risk perception influences decision-making concerning job safety consequently, being able to recognise worksite hazards and then accurately perceive the associated risks are critical skills that lead to safe work decisions.

Research on hazard recognition as a critical skill identified tasks designed to test worksite hazard recognition abilities and put a recognition rate of at least 90 percent as the standard for mastery of the skill. Workers tended to underperform in tests using this criterion (Bahn, 2013; Perlman et al., 2014 cited Eiter et al., 2016).

4.5.1 Factors impacting on a person’s ability to recognise worksite hazards

Researchers focused on the construction industry where they compared the hazard recognitions of groups with different amounts of workplace experience and contrary to their prediction, safety Directors outperformed superintendents and civil engineering students, a result which they attributed to experience and formal safety training that the superintendents and students did not have. Further, a lack of recent experience working in a particular environment, such as in situations of layoffs or filling in for an absent employee, can also have an impact on hazard recognition abilities (Barrett & Kowalski, 1995 cited Eiter et al., 2016). According to the MQA (2018), among the reasons provided by employers and stakeholders for some of the hard-to-fill occupations in the South African MMS is a lack of high-level experience needed in senior positions.

Personal experience from a work-related incident can also affect risk perception, for example, a worker who had experienced a “near miss” is more likely to perceive a similar situation as risky or hazardous than he or she would have before the experience (Burke et al., 2007 cited Eiter et al, 2016).

NIOSH researchers inspected the fatalities that occurred between 2009 and 2014 at surface SSG mines to determine what types of tasks mine workers were performing when the fatal injuries occurred. They found that 75 percent of fatalities were sustained while performing routine tasks. A routine task is one that takes place with regular frequency so mineworkers are typically familiar with the job process, the work environment, the required personal protective equipment and the potential hazards and risks associated with the task. A non-routine task is one that falls outside of a worker's normal duties, does not have a documented standard operating procedure (SOP), is performed in a different way than the SOP, or is a task that has never been performed before (Eiter et al., 2016).

The results showed that identified hazards varied by job type and task frequency. With regard to job type, seven out of eight miners identified hazards as critical based on what they were exposed to during their day-to-day jobs. For instance, a pit loader operator identified ground control issues such as falling rock as the most risky and being aware of the location of haul trucks as the second most risky aspects of his job.

4.5.2 Job control

Job control in risk management relates to the capacity of employees to take action to address risk and to influence the nature and pace of their work. When employees are unable to make changes to address risk and cannot have a say in how they undertake their duties, risks can be neglected with a potential for adverse events and employees are less likely to report issues requiring attention (Mine Health and Safety Council, 2010).

The miners' perceptions of how much control they have over their surroundings also influence the hazards identified in relation to the jobs they perform. Locus of control is the extent to which people feel they personally control the events in their lives as opposed to those events being controlled by the external environment (Judge et al., 2002 cited Eiter et al., 2016). In the study carried out by Eiter et al. (2016), miners’ reported concerns related to how their safety was affected by the safety practices of others over whose actions they had no control. An example relates to vehicles on site that were not operated by mine employees. The miners expressed concerns about customer truck drivers because they have no control over a customer truck driver's actions and, because they do not work with these drivers on a daily basis, they have a difficult time predicting what these drivers will do.

A majority of the miners discussed differences in hazard identification and perceived risk while performing routine and non-routine tasks. Maintenance and repair tasks such as greasing rollers, replacing beltlines and removing build-up from walkways and conveyors are examples of routine tasks at a surface SSG mine. A majority of the miners interviewed said routine tasks are more hazardous than tasks they do not perform regularly. One said, “Probably the ones you do daily are riskier; probably because you get in such a routine. Because if I'm helping someone else, a lot of times I'll stop and ask, but when you do something that's routine, you get so used to it, it can turn into something bad” (Eiter et al., 2016).

As one explanation, miners said they considered routine tasks as more hazardous because they take less precaution: “If you've done it so much you're comfortable with it, you know, I know from previous jobs if you become comfortable with something you don't really take as much precaution as you should or something along that lines.” Miners also get complacent: “I don't see a difference between tasks that happen often and tasks that don't. Miners get complacent when they do particular tasks every day.” “On a daily basis I am safe, but there are some things I get complacent with. For example, I sometimes shovel the chutes without gloves on and sometimes I step or stand on the handrails, and I don't always wear my hearing protection ... Sometimes I can stand on a guard to reach something instead of going and getting a man lift.”

The miners indicated that non-routine tasks are less hazardous than those performed routinely. They perceived non-routine tasks to be less hazardous because they have to pay more attention to what they are doing. They work as a team and spent time planning ahead for a non-routine task, suggesting that safety awareness increased for tasks that are not done often. The data also indicated the miners understand the importance of clear and consistent communication with co-workers during non-routine tasks.

The miners also perceived actions and situations that are out of their control as being hazardous. An example given was interactions with customer trucks, as they do not share knowledge with customer truck operators and are therefore unable to predict the actions of these drivers.

How often the miners performed a task not only affected the way they thought about the task but also how they got together to perform the task. The majority of the miners indicated they perceived routine tasks as being more hazardous than non-routine tasks because they tended to take fewer precautions with routine tasks. They also reported becoming complacent while performing routine maintenance and repair tasks.

4.6 SUMMARY OF FINDINGS AND IMPLICATIONS FOR THE STUDY

The review revealed that organisations in the MMS have shifted in risk management from a focus on human factors to technology to eliminate risks at source coupled with investigating root causes of accidents and job safety analysis. Safety in mines has improved but mining remains more dangerous than other economic activities. Therefore, it is not enough to measure lagging indicators such as fatalities, injuries and disease. Events leading to incidents must also be detected to prevent the negative outcomes. The risk management process is one way of dealing with this and consists of continuously identifying, eliminating or reducing risks in the early design phase and throughout the mining lifecycle.

The review found that better performing mines in the MMS treat risk management as an integral part of mine operations and take a more proactive approach rather than reacting to events. A blame-seeking approach to managing risks and incident investigation is a key precursor to major industrial disasters and this was identified to be a strong feature of the MMS in South Africa. Though more significant at the lower end of the organisational hierarchy, blame issues are a problem throughout the organisational levels that has the consequence of reducing accident reporting.

Risk management is at the heart of the MHSA 1996 and to be effective, the process requires the presence of the hazards with potential for different types of accident; facilities, machinery and equipment to match the hazards; systems and procedures to match the hazards, facilities and equipment; adequate organisation; a high level of emergency preparedness, and a committed management.

Errors and violations present an opportunity to identify potential risks in mining operations and environment. Thus, a blame approach to incident investigation that is satisfied with identifying who made an error is not useful in preventing recurrence and may even be counter-productive because it encourages non-reporting and makes it more difficult for an incident investigation to gain all relevant information about the incident.

With regards to factors influencing risk management in the MMS, reviewers found that the South African MMS is faced with the challenge of dealing with risks arising from natural causes such as seismic activity and methane explosions that cannot be eliminated but action must be taken to reduce or control these risks at source. The ways in which such controls are developed and implemented including the organisational culture that determines their context can affect the effectiveness of the controls. Organisational cultures of workplaces that control risks more effectively have features that enable them to anticipate adverse events and respond to them effectively after they occur.

Reviewers examined views on the impact of production, bonuses and incentive schemes on the risk management process. The main differentiators of sites in the MMS were the choices made when risk control measures had production or financial implications. Taking shortcuts was not only ignored, but actively reinforced by line managers on some mine sites. Production bonuses often encourage underground mine employees to hide accidents in order to meet their production targets and qualify for the bonus system.

The European Union adopted an innovative strategy of using economic incentives from sources outside the company such as tax reductions and insurance-related incentives to support improvements in OHS performance at work and notifiable accidents dropped in beneficiary companies.

We also found that effective workforce engagement is an important factor influencing risk management in the MMS. Workers in the MMS 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 in the risk management process. Workplaces where workers and supervisors were involved heavily in planning the work, tended to be the mines where there were fewer accidents.

Incident reporting is a critical support to effective risk management, while supervision is a fundamental safety function within all levels of an organisation. It complements the requirement to provide information, instruction and training, and influences how well organisations achieve the safety and health objectives of the MHSA, 1996. Management support for frontline supervisors is critical in risk management and it should ensure that people with supervisory responsibilities know what is expected of them.

With regard to the risk management process, literature construes the risk management process as the continuous process of controlling risks and consists of specific steps: establishing the context and scope of the assessment process; Identifying the hazard; analysing the risk; treating the risk; communication and consultation; monitoring and review of controls.

A best practice in fatigue risk management in a US mine showed that targeted changes can be made at a mine to increase the health, safety and happiness of the employees, but mine management needs to be in touch with the workforce to effectively implement and recognise the value of the changes. Other best practice identified is the development and publication of practical guides on risk management for use on mines for people to develop their understanding and experience by encouraging a daily discipline of managing risks whilst carrying out tasks in the mining and quarrying industries.

Reviewers focused on risk recognition and risk perception among mine workers as factors affecting their ability to recognise hazards and contribute to controls. The health and safety of workers depend on their deciding whether to remove hazards and mitigate risks and how to do so. This makes it critical that miners are able to recognise site hazards and accurately assess their risks. Hazard recognition is therefore a realisation that a condition or behaviour can cause harm and it is a necessary skill for all mineworkers.

Literature suggests that experience and formal safety training impacts on employee ability to recognise and control hazards. Further, a lack of recent experience working in a particular environment, such as in situations of layoffs or filling in for an absent employee, can also have an impact on hazard recognition abilities. Lack of high-level experience needed in senior positions was one of the reasons given by employers and stakeholders for the hard-to-fill occupations in the South African MMS. However, fatalities studies show that most fatalities were sustained while performing routine tasks in which miners are familiar with the job process, the work environment, the required personal protective equipment and the potential hazards and risks associated with the task. And seven out of eight miners identified hazards as critical based on what they were exposed to during their day-to-day jobs. Hence, personal experience from a work-related incident can also affect risk perception.

The miners' perceptions of how much control they have over their surroundings also influence the hazards identified in relation to the jobs they perform. Miners perceive routine tasks as more hazardous than tasks they do not perform regularly because for routine tasks they take fewer precautions or get complacent while they have to pay more attention to what they are doing for non-routine tasks.

These findings indicate the importance of workers' job-related experience, particularly the relevance of a task to that job, and whether or not they have personal control over that task. Additional research is suggested to understand factors such as mining operation size, and conditions like underground versus surface mining.

Based on these findings, the research team identified areas for skills development to improve OHS performance in the South African MMS:

- We suggest a strategy to improve hazard recognition abilities of miners through training: develop and deliver specialised training to provide miners with skills to identify commonly encountered, difficult to see or unknown hazards. The training should be relevant to the audience and environment and target hazards miners commonly encounter in the tasks they routinely perform.
- A competency based OHS awareness training programme covering the skills, knowledge and attitudes required to apply occupational health and safety in the workplace. Workers are able to demonstrate competency in performance criteria that include among others, recognising workplace hazards, assessing their risks and responding to them.
- A competency-based training for supervisors starting with a needs assessment to help identify the required competencies, training needs and skill gaps, skills for

future development as well as the desired skills to be assessed during recruitment. Once gaps in training and assessment have been identified, an effective training solution can be developed and implemented. Training content will depend on the individual capabilities of the supervisors and can focus on areas such as: task instruction; hazard identification and risk evaluation; team building and leadership; time management; running meetings; information gathering and report writing; incident investigation; providing feedback; conflict resolution and emergency management.

CHAPTER 5

REVIEW OF LITERATURE ON THE NATURE OF EDUCATION AND TRAINING INTERVENTIONS TO SUPPORT OHS PRACTICE IN THE MMS

Reviewers explored relevant literature focusing on the nature of education and training interventions in support of OHS practice in the MMS.

5.1 LEGAL AND INSTITUTIONAL FRAMEWORK FOR EDUCATION AND TRAINING IN THE MMS

Mine Safety and Health Convention 1995 (ILO C 17*6*)

The Occupational Safety and Health Convention No. 155, 1981 (ratified by South Africa 18th February, 2003) is the primary ILO convention on occupational safety and health providing foundation for the OHSA, 1993 of South Africa, but the specific Convention relating to OHS in mining is the International Labour Organisation's Safety and Health in Mines Convention 1995 (No. 176) and ratified by South Africa on 09/6/2000 seeks to protect the health and safety of mine workers by recommending the application measures to make mines free from fatalities, injuries and diseases (Zungu, 2012). The Convention applies to all mines. South African OHS Law and Regulations prescribe the measures for ensuring the application of the provisions of the Convention and designate the competent institutional framework (MHSC, DMR, MQA and Tripartite Consultative Committees) to monitor, regulate and facilitate the implementation of the various aspects of OHS in mines.

According to the provisions of Convention C176, each ratifying member should have a coherent policy on health and safety in mines (Higert, 2015). This ensures continuity and certainty to be able to effect transformation, and to continue to sustain and grow investment in the sector (Anglo American, 2016). National Law should provide for the supervision of OHS in mines; the inspection of mines by designated inspectors of the competent authority; the procedures for reporting and investigating fatal and serious accidents; the compilation and publication of statistics on accidents, occupational diseases and dangerous occurrences; the competent authority to suspend or restrict mining activities on safety and health grounds until conditions giving rise to the suspension are addressed; worker consultation on matters related to safety and health in mines. These provisions are explained and supplemented by Recommendation No. 183 (ILO, C176).

The implementation of the provisions of Convention C176 as incorporated in South African legislation, notably the OHSA, 1993 and the MHSA has meant that the South African Government, through the MHSC, DMRE and the MQA in particular, as well as the mining industry must deal with challenges related to the availability of people with the required competencies and skills to assume the stipulated roles. The MHSC's primary tasks are to advise the Minister of Mineral Resources and Energy on occupational health and safety legislation and research outcomes focused on improving and promoting occupational health and safety in South African mines. The MHSC works closely with the Mining Qualifications Authority (MQA), which plays a critical role in addressing skills shortages and gaps in the mining industry through capacity development and process improvement. The MQA is mandated to ensure that the mining and minerals sector has sufficient numbers of competent people who have been trained to improve health and safety standards and processes (This is Gold, 2018).

Various pieces of South African legislation and policy documents provide assistance in the transformation and improvement of health and safety standards in the MMS including skills development (Ntsuxeko, 2017). These include, but are not limited to the OHSA 1993, MHSA 1996, the Skills Development Act of 1998 (SDA), Minerals Petroleum Resources and Development Act 2013 (MPRDA), 1996, Employment Equity Act, 1998, Mining Charter 2018.

The Mine Health and Safety Act No. 29, 1996

The Occupational Health and Safety Act (OHSA) 85 of 1993 is the most far-reaching legislation in OHS in South Africa, applying in all contexts except mining, which has its own dedicated legislation, the MHSA No. 29, 1996 governing OHS (Tuchten, 2011; Hermanus et al., 2016; Mojapelo et al., 2016; DMR, 2018). The OHSA is administered by the Department of Labour and Employment but in special circumstances, Section 80 of MHSA states that the Minister of Minerals Resources may make specific provisions of the OHSA applicable to a mine after consulting with the Mine Health and Safety Council. Mines and quarries are regulated by the Mine Health and Safety Act (MHSA) 29 of 1996 and Amendments thereof and administered by the DMRE (Tuchten, 2011). This is explained by the hazardous nature of mining and the reality that the South African mining industry is characterised by the anomaly of undergoing huge technological developments accompanied by a largely unskilled or semi-skilled workforce, a combination that increases the scope of occupational hazards significantly enough to merit health and safety legislation distinct from OHSA 1993 governing the rest of South African industry (Joubert, 2007 cited Tuchten, 2011).

The objectives of the MHSA are to protect the health and safety of persons at mines; to require employers and employees to identify hazards and eliminate, control and minimise the risks relating to health and safety at mines; to give effect to the public international law obligations of the Republic that concern health and safety at mines; to provide for employee participation in matters of health and safety through health and safety representatives and the health and safety committees at mines; to provide for effective monitoring of health and safety conditions at mines; to provide for enforcement of health and safety measures at mines; to provide for investigations and inquiries to improve health and safety at mines; and to promote a culture of health and safety in the mining industry through training in health and safety in the mining industry; and co-operation and consultation on health and safety between the State, Employers, Employees and their representatives (MHSC, 2014).

The MHSA requires the employer to provide health and safety in the workplace, including the costs for hazard identification and control and the provision of medical surveillance where applicable. The MHSA of 1996 is a shift away from prescriptive regulation to more risk-based management of health and safety in the mines, allowing employers to choose how best to manage health and safety to prevent and mitigate risks in the mining workplace. The sections of the MHSA most relevant to skills development are those which relate to training and affect every employee. Education and training in the mining sector are dealt with in detail in Section 10 of the MHSA.

According to Section 10, MHSA, 1996 managers (rather than the employers) must provide OHS training to all employees for free. The Act states that:

1 As far as is reasonably practicable, every manager must:

- Provide employees with any information, instruction, training or supervision that is necessary to enable them to perform their work safely and without risk to health.
- Ensure that every employee becomes familiar with work-related hazards and risks and the measures that must be taken to eliminate, control and minimise those hazards and risks.

2 As far as is reasonably practicable, every manager must ensure that every employee is properly trained:

- To deal with every risk to the employee's health or safety that (i) is associated with any work that the employee has to perform; and (ii) has been recorded in terms of section 11.
- In the measures necessary to eliminate, control and minimise those risks to health or safety.
- In the procedures to be followed to perform that employee's work.
- In relevant emergency procedures.

3 In respect of every employee, the provisions of subsection (2) must be complied with:

- Before that employee first starts work.
- At intervals determined by the manager after consulting the health and safety committee.
- Before significant changes are introduced to procedures, mining and ventilation layouts, mining methods, plant or equipment and material.
- Before significant changes are made to the nature of that employee's occupation or work.

According to amendments passed in 2008, employers must keep a record of all training provided, and all mines must submit a workplace skills plan and annual training reports to the MQA. These provisions set the stage for OHS practice, education and training in the MMS.

Literature identified three approaches to the provision of OHS training in the MMS arising from the recommendations of the Leon Commission and provisions of the MHSA, 1996: (1) that workers should be trained to execute particular operations in ways that combine self-protection with the avoidance of risks to fellow workers and others who may be affected, including the general public; (2) that induction and refresher training should be designed for all ranks of mine officials, and should focus on the problems that represent the greatest risk to health and safety and, (3) that Adult Education (ABET) is a primary intervention for health and safety in the MMS (Tuchten, 2011). Institutions such as the MHSC and MQA provide the support base for education and OHS training in the MMS.

Hazardous Substances Act No. 15, 1973 as amended

The Hazardous Substances Act provides for the control of substances such as chemicals, biological agents, dusts and fumes in any workplace including mining, which may cause injury or ill-health to or death of human beings by reason of their toxic, corrosive, irritant, strongly sensitising or flammable nature or the generation of pressure thereby in certain circumstances, and for the control of certain electronic products in the workplace. The Act provides for the division of such substances or products into groups in relation to the degree of danger; the prohibition and control of the importation, manufacture, sale, use, operation, application, modification, disposal or dumping of such substances and products.

The MHSA, 1996 provides for the enforcement of the Hazardous Substances Act by requiring the manager of a mine to identify hazards and risks in the mining workplace and prevent or control them (Section 11, MHSA); to conduct occupational hygiene measurements to identify hazardous substances in the work environment (Section 12, MHSA); conduct medical surveillance of employees to detect early signs of disease due to exposure to chemical and biological agents at work and keep records (Section 13, MHSA). This requires specialised training and skills development in the handling and application of hazardous substances in mineral processing and use of explosives.

The Minerals Petroleum Resources and Development Act No. 28 2002

The Minerals Petroleum Resources and Development Act (MPRDA) repealed the Minerals Act No. 50 of 1991 which did not address the environmental issues in the MMS and is aimed at enabling a fair participation of Previously Disadvantaged South Africans (PDSAs) in the MMS (Ntsuxeko, 2017). The MPRDA is aimed at creating conditions that are conducive for equitable access and sustainable exploitation of petroleum and mineral resources in the country by empowering HDSA with skills and participation in managerial positions in the MMS (MQA, 2019).

More specifically, the MPRDA recognises the internationally accepted right of the State to exercise sovereignty over all the mineral and petroleum resources in South Africa; promotes equitable access to the national mineral and mineral resources to all the people of South Africa as well as employment in order to advance the social and economic welfare of all South Africans (Chapter 2, MPRDA).

Skills Development Act of 1998 (SDA)

The SDA aims to improve the quality of life of workers, their prospects of work and labour mobility through the development of their skills; to improve productivity in the workplace and the competitiveness of employers; to promote self-employment; and to improve the delivery of social services; to increase the levels of investment in education and training in the labour market and to increase the return on that investment; to encourage employers - to use the workplace as an active learning environment; to provide employees with the opportunities to acquire new skills (Ntsuxeko, 2017). Providing high-quality training is a key attraction and retention tool and enabler of transformation within and beyond the workplace (Anglo American, 2016).

The SDA seeks to provide opportunities for new entrants to the labour market to gain work experience; to employ persons who find it difficult to be employed; to encourage workers to participate in learning programmes; to improve the employment prospects of persons previously disadvantaged (HDSA) by unfair discrimination and to redress those disadvantages through training and education; to ensure the quality of learning in and for the workplace; to assist - work-seekers to find work; retrenched workers to re-enter the labour market and employers to find qualified employees. Anglo American approach includes providing employee training, specific career-development interventions, performance management and development, coaching, mentoring, succession planning and high-potential employee identification and 'fast-tracking', which aims to address the under-representation of HDSA employees in various technical fields, with a focus on supervisory and managerial categories (Anglo American, 2016). Employee education and training is critical for the prevention or reduction of fatalities, injuries and diseases in the MMS and requires stringent development, facilitation and oversight (Ntsuxeko, 2017).

The MQA was created under Sections 45 and 46 of the MHSA and is the accredited Skills Education Training Authority (SETA) for the mining and minerals industry in accordance with the Skills Development Act. The MQA has established a qualification and standards unit for the mining sector to meet SAQA requirements and operates as an approved Education and Training Quality Assurance (ETQA) body for the mining industry. MQA is mandated to ensure the provision of skills to previously underprivileged group in order to achieve long-term success to the mining transformation (MQA, 2019) and formulates Sector Skills Plan and appraises it to ensure that the SETA has relevant, up-to-date information and analysis to allow it to perform its strategic skills planning function for the sector, and to maximise participation by employers in the National Skills Development Strategy through the efficient use of resources available for training within the MMS.

Employment Equity Act No. 55 1998

There are disparities in employment, occupation and income within the national labour market that create such pronounced disadvantage for certain categories of people that cannot be redressed simply by repealing discriminatory laws (Ntsuxeko, 2017, MQA, 2019). The Act seeks to promote the constitutional right of equality and the exercise of true democracy, eliminate unfair discrimination in employment, ensure the implementation of employment equity to redress the effects of discrimination, achieve a diverse workforce broadly representative of the South African people, promote economic development and efficiency in the workforce, and give effect to the obligation of South Africa as a member of the International Labour Organisation (Ntsuxeko, 2017).

The Act mandates the employer to promote equal opportunity in the workplace by eliminating unfair discrimination in employment policy or practice; every designated employer must, in order to achieve employment equity, implement affirmative action measures for HDSA, including but not limited to developing people from designated groups in all occupational categories and levels in the workforce; retain and develop people from designated groups and implement appropriate training measures including measures in terms of the Skills Development Act (SDA) (Ntsuxeko, 2017). In the mining workplace, Anglo American employment equity profile in 2016 showed that while African females in the workforce improved their representation in 2016 relative to the Employment Equity Act (EEA), they remain the most significantly under-represented group. African male representation at management levels was above the EEA, but the majority of these employees were at junior-management level. The representation of white males across the workforce was aligned with the EEA; the majority, however, were in management positions (Anglo American, 2016). The EEA encourages skills development and career advancement for Historically Disadvantaged South Africans (HDSAs) in the MMS (MQA, 2019).

The Mining Charter, 2018

The new Mining Charter is entitled Broad-Based Socio-Economic Empowerment Charter for the Mining and Minerals Industry and is the third edition of the policy document, the first and second having been issued in 2000 and 2004 respectively. The Charter stipulates rules aimed at distributing the mineral wealth accruing from the MMS more equitably among all South Africans as well as to drive investment and growth in the industry (Ntsuxeko, 2017; DMRE, 2018).

The Mining Charter, 2018 derives from the Mineral and Petroleum Resources Development Act, 2002, (Act No. 28 of 2002) (MPRDA) which mandates the Minister of Mineral Resources to develop the Mining Charter to ensure transformation within the mining and minerals industry (DMRE, 2018). It requires the MMS to implement various elements, among them Human Resources Development and Employment Equity that are directly relevant to this study. With regards to Human Resources Development element, the Charter requires mining right holders to implement a 5% investment on essential skills development activities, graduate training programmes and research and development initiatives (DMRE, 2018). Concerning Employment Equity, the mining right holder must submit and obtain approval for a five-year Employment Equity Plan detailing the targets for progressively realising the Mining Charter, 2018 (DMRE, 2018).

Racial and gender disparities persisting within the demographic composition of the MMS are indicative of the need to continue addressing workforce imbalances. The present study is an implementation of the MQA research agenda with outcomes based on skills development and aligned to transformation of the MMS (MQA, 2019).

5.2 KEY CHANGE DRIVERS SHAPING SKILLS DEVELOPMENT IN THE MMS

Various change drivers have been identified that impact skills demand and development in the MMS. According to the MQA (2018), the integration of advanced technology in the mining process is transforming the skills demand within MMS, placing a new demand on the type, level and mix of skills and qualifications required by the sector. It is therefore becoming imperative for employers to equip employees with relevant emerging skills to ensure that they are well versed with the digital and technologically advanced space brought by the fourth industrial revolution. A focus, for example, could be starting to train plant operators and elementary workers to operate new machinery and coordinate new processes that support their progression towards technical occupations. Senkhane (2019) indicates that in 2018, increase in technology spending to improve worker safety and operational performance ranked as top driver of change and 2019 has seen a move towards using digital sensors, location tracking wearables, and mobile apps are expected to be widely used.

For example, to curb underground accidents, the MHSA 1996 requires that miners be removed from working face dangers and hazards where possible, failing technological methods can be used to protect workers. Mines have introduced innovative technology in hauling broken rock that relies on an electronic control system that incorporates remote sensing built into the underground trains that transport the rock (This is Gold, 2018).

In their 2016 annual report, Anglo American gave examples of modernised equipment deployed in their operations: proximity devices fitted to control safe movement of locomotives; Personnel detection sensors and other sensory and lighting technology to improve personnel safety; new tank-house technology at the base metal refinery in Rustenburg improved work environment by reducing ambient tank-house acid-mist emissions; large-scale fine-grinding technology improving PGM liberation and downstream extraction and improving recovery by 3%.

Empirical studies have confirmed that improved technology reduces underground mining accidents. For example, "radio remote-control technology" was introduced in Canada for underground mining. The benefits of tele-remote technology include "a more office-like work environment for equipment operators. There is little noise, vibration, no fumes and no rock fall hazards. It is also possible for one miner to control more than one machine" (Eweje, 2019). However, literature suggests new technology may come with new hazards and these require specialised skills to recognise and deal with them. For example, Jennings (2001) stated that some new technologies have been accompanied by new or intensified hazards – such as dust, noise, vibration, ergonomics-related problems, and electric current.

Many deep-level South African gold mines are achieving safety performances that compare favourably with international benchmarks set in countries such as Canada and Australia. Strategies to further improve mining methods and technologies include removing people from the working-face underground, as well as improving safety attitudes and practices. A great deal of attention is currently being focused by gold mining companies on the development of processes and technologies that will remove – as far as possible –individuals from the rockface so as to minimise the threat of injury. The introduction of mechanised operations at some mines, for example, has seen a radical improvement in safety performance (This is Gold, 2018).

Key drivers such as enterprise development impact on job creation. Community unrests and the impact of HIV/AIDS create a loss of key skills and replacement costs. Energy and water efficiency, as well as the reduction of pollution, are increasing imperatives creating the need for skilled workers to source ‘green’ products and services and manage ‘green’ supply chains (MQA, 2018).

Downscaling and closing of operations in the MMS due to globalisation of markets lead to retrenchment of mineworkers needing new jobs. The challenge is to re-skill or up-skill those retrenched with skills to enable them gain access to the job market.

Current South African legislative instruments promote opportunities leading to transformation and career growth for the workforce in the MMS and this demands novel initiatives in skills development (MQA, 2018). Legislation provides the framework of standards and direction and the regulatory authority is charged with enforcing compliance. New regulations are highlighting the responsibility and liability of mine managers and make it a requirement that they manage health and safety and provide a safe place to work (Jennings, 2001). This trend is visible in international mining practice.

In 2017 the Queensland Mines Inspectorate revised its organisational structure to create two distinct operating streams; Coal, and Mineral Mines and Quarries. The new arrangements better enable the delivery of responsive, targeted compliance programmes and initiatives, across the state (Department of Natural Resources and Mines, 2017). Importantly, fatal hazard data for Queensland mines is consistent with Australian mining trends over time, whereby the nature of fatalities has shifted away from multiple fatalities, to incidents resulting in individual loss of life. This shift has been attributed in part to technological developments, as well as improved legislative and regulatory frameworks, more proactive safety management systems, and better risk management practices. Sustaining these improvements is dependent however on continued alertness to fatal hazards; data on serious accidents and high potential incidents demonstrate there is no room for complacency (Department of Natural Resources and Mines, 2017)

These changes require new skills or up-skilling of existing workforce as stated succinctly by the MQA with regard to the MMS where increasing integration of new technology in mining to extend mine lifespan as well as attain improved production and efficacy in safety, introduces a critical need for up-skilling of the workforce to cope with the transforming landscape and also deal with possible job losses. The burden will mostly lie on employers to equip their workforce with new skills consistent with the digital and technological advances (MQA, 2019).

The MQA provides SMMEs with assistance and support to acquire skills which they lack at start up and during operation. This is important because the MHSC (2000) small-scale mines baseline survey revealed deficiencies in risk management competencies among small mines despite the fact that they face the same hazards as larger mines.

Fatalities and injuries have moved downward but persisted. There is concern about the accidents related to seismicity resulting to rock bursts and rock falls, major causes of fatalities and injuries in the MMS. There is a need to develop qualifications and learning programmes in the area of seismology. In addition, MQA will have to develop green skills to enable the MMS manage the environment sustainably.

The MQA has a Mine Community Project in partnership with TVET colleges in mining areas that will train unemployed youth in mine communities. It includes focus on supporting Maths and Science in schools to address skills shortages in the long-term.

5.3 THE EFFECTIVENESS OF ADULT BASIC EDUCATION AND TRAINING (ABET) AND ITS IMPACT ON OHS PERFORMANCE IN THE MMS

Mine accidents involve lower-grade operators comprising the majority of labourers and occupations including drillers and winch operators and it is assumed that poor OHS performance in the MMS is related to workers not being literate and the risks associated with mining hazards will affect the lives of illiterate employees. Fatal accidents occur regularly among mineworkers in the age group 40-49 with long experience working underground (Frankel, 2010; MHSC, 2009; Tuchten, 2011 cited Botma, 2015). ABET was derived from an assumption that low levels of formal education in the MMS negatively affect health and safety. And ABET would contribute to improving OHS performance through literacy, enhanced awareness and self-concept. However, the author indicates, the negative effect of under-education is not analysed. The contribution of under-education to fatalities, injuries and ill-health have not been researched and demonstrated.

Botma (2015) conducted a study to determine the impact of Adult Basic Education and Training (ABET) on Occupational Health and Safety (OHS) and the contribution of Adult Basic Education and Training (ABET) to possibly lower fatalities in the Mining sector through continuous efforts to increase the literacy levels of its workforce. Two of the objectives of the study were to determine the impact of ABET on OHS in the MMS and whether ABET and OHS awareness in the MMS are correlated.

The researcher concluded that ABET improves safety in the workplace and helps to eliminate illiteracy levels and that the higher the literacy levels, the better employees are able to interpret and understand safety requirements, improving compliance and responses to risks, indicating a direct correlation between literacy and safety (Botma, 2015). The initial objectives and expected outcomes of ABET in relation to OHS practice and performance in mines against which the efficacy of the programme could be measured were not specified. There is no indication in literature of a tie between ABET and reduction in accidents or occupational illnesses. One way of assessing the impact of increased literacy level on performance is by accident causal analysis.

South African literature points out that while a programme such as ABET has the potential to promote capable workers lacking in formal education and respond to those who want a second chance in education, there is a declining enrolment into the programme as few workers have the time or interest to participate. Unacceptably high rates of fatalities, injuries and occupational diseases underground occur alongside both ABET and dedicated OHS training endeavours, indicating the need for a review of OHS training initiatives in mines informed by a baseline study of the current provision of training and preparation of mine workers (Tuchten & Nkomo, 2012).

According to Tuchten and Nkomo (2012), uptake and scale of ABET as a driver of OHS improvement in mines are negligible. ABET may be successful in raising OHS awareness among miners but mainly yields personal benefits to those who participate including expectations for promotion. Most workers are relatively uneducated and may not qualify for registered programmes and thus require alternative methods of preparation and training for the hazardous tasks.

The South African author Tuchten (2011) has pointed out that the OHS training logic of the MHSA originated in the Leon Commission of 1994 and has three foci: task- or operator-specific training, ABET, and hazard-specific training. However, these categories of training are not fully addressed in the information available on OHS training and task-specific training is the intervention that currently shows evidence of progress. According to the author, the hazard specific aspects of OHS training on critical issues such as lung health appear to be neglected, while there is limited evidence of dedicated OHS training for mineworkers, focussed specifically on problems that represent the greatest risk to health. Tuchten (2011) suggests that the low showing of ABET is an indication that it is necessary to facilitate comparable awareness and mastery of health and safety subjects outside of ABET structures.

There is no indication of how ABET will deal with young entrants into the MMS. Language is also an issue in OHS training and practice, for example, risk assessment processes and computer-aided virtual-reality equipment have unique and valuable uses in OHS training, but may not applicable to all issues (Tuchten, 2011) and certain categories of the workforce.

There is indication in South African literature that literacy improves workplace safety because employees can read and understand warning signs and ABET helps learners to read and understand safety warnings, instructions, company briefings as well as communicate better (Tuchten & Nkomo, 2012). In this study all mines commented that ABET employees are more aware of OHS issues at work including HIV/AIDS, malaria and TB. The researchers suggest that the low uptake of ABET across the mining sector indicates that it is necessary to facilitate OHS skills and awareness outside of ABET structures and to pursue and develop new ways of doing so. Lung health awareness of mineworkers provides an illustrative example because: “Many employees have little or no understanding of the processes that lead to occupational lung disease, their consequences, how to protect themselves from the conditions” (Tuchten & Nkomo, 2012).

Tuchten and Nkomo (2012) drew important lessons from their study including that: most underground mineworkers did not complete their schooling; uptake and scale of ABET in mines and possible effects on OHS effectiveness in negligible; ABET yields mainly personal benefits to participating miners which may include enhanced OHS awareness; all mine workers require adequate preparation and training for the mine workplace but most are relatively uneducated and do not qualify for registered programmes; and the need for additional OHS initiatives to provide mine workers with comprehensive preparation and training for the mining hazards and risks. Individual mining companies perceive in-house or on-the-job training more cost-effective than external training (Anglo American, 2016).

5.4 NATURE OF OHS TRAINING INTERVENTIONS IN THE MMS

Literature draws a distinction between OHS training and worker education: OHS training instructs workers in recognising known hazards and in using available controls for protection, whereas worker education prepares a person to deal with potential hazards or unforeseen problems, giving guidance in ways to become better informed and to seek actions aimed at eliminating the hazard. The distinction between worker training and education programmes is blurred and often depends on the role that the worker will assume after the programme: the narrower the role, the more the instruction is training and the broader the role, the more the instruction is education (Cohen & Colligan, 1998).

Education and training are one of the important elements of a successful accident prevention programme (NIOSH, 2001; Shamsuddin et al., 2014). An employer is obligated to provide "to employees, in appropriate languages, the information, instruction, training and supervision necessary to enable them to perform their work in a manner that is safe and without risk to their health. For instance, provide education and training to workers in a language and vocabulary they can understand to ensure that they know about procedures for reporting injuries, illnesses and safety and health concerns, method on how to recognise hazards, correct ways to eliminate, control or reduce hazards. Management must conduct refresher education and training programmes periodically to raise their awareness. The education and training programmes for staff may include a structured training regime for employees, encompassing on job training, refresher training and OSH Consultation training.

Sound basic education for work, certified induction and refresher training, and certified company-specific training as part of lifelong learning, are crucial for the implementation of effective health and safety hazard prevention programmes. These must be supplemented by specific seminars and refresher training and improvement programmes – for trainers and for managers, supervisors and workers (Jennings, 2001).

While training is a critical tool in reducing occupational health disparities, but its effectiveness may be limited if offered in isolation from other interventions. Training workers to use appropriate PPE, for example, is of limited value if they lack sufficient power in their relationship to their employer to demand such equipment (O'Connor et al., 2014).

South African mining companies recognise the critical role education and training play in sustaining mining and invest in employee training and development through learnerships, bursaries, portable skills, internships and adult education. Top-class training and development enhance employee safety and productivity and the opportunities offered attract and retain the best talent in the industry. In addition to employee training, approaches include career development, performance management, coaching, mentoring, succession planning and fast tracking of employees with high potential (This is Gold, 2018).

Generally, the mining sector in South Africa has evolved over the years and this has also resulted in the evolution of the workforce from a predominantly uneducated to a more educated workforce. Without some basic education, training in health and safety becomes more challenging. Analysis of qualifications reported in the WSP-ATR submissions reveals that the highest proportion of employees (48%) in the MMS have achieved between Grade 10 (including N1 and NCV1) and Grade 12 (including up to N3 and NCV3). Employees who fall in the bracket between a Higher Certificate and Post-Doctoral Degree account for 17%, whilst those who have achieved between Grade 4 (including AET1) and Grade 9 (including up to AET 4) constitute 16%. Approximately 1% of the sector's employees have no schooling at all. The "Undefined" category represents the employees whose education levels were not specified in the WSP-ATR submissions (MQA, 2018). This is a concern for the sector posing a risk to the sector skills development and the drive towards the zero harm milestones in the MMS, setting the tone for skills training in OHS in the MMS.

The Mine Health and Safety Act (MHSA) entrenches basic worker rights, most notably, the right of workers to participate in health and safety matters, the right to receive health and safety information, the right to receive training relating to health and safety at work and the right to withdraw from the workplace in the face of dangerous work and/or environment (Section 23 (1) (a) (MHSA, 1996).

Statistics indicate that total employment in the MMS has declined from a peak of 628750 in 2012 to 493 471 in 2018, a -3% annual average decrease in overall employment figures during the 7-year period. According to the MQA, since 2012, there has been a decrease in employment numbers across most occupational categories, with the most significant in the Elementary occupations (-5%). The Learners and Trades categories are the only occupations to have shown growth in average numbers over the period, with a 5% and 2% increase respectively.

The prevailing situation has implications for skills development and OHS practice in the sector. For example, retrenchments are a reality in the foreseeable future requiring key role players in the MSS to consider re-skilling and up-skilling of ex-mine workforce a priority to provide them the mobility to be absorbed in other sectors of the market (MQA, 2018).

According to Table 5.1, the MMS continues to be a significant employer in the SA economy with about 500,000 jobs. Though Section 23 (1) (a) of the MHSA, 1996, confers the rights to employees in the MMS to receive OHS training , between 2013 and 2018, only an average of 1% of MMS employees received OHS training annually, showing a huge deficiency in training expectations. For example, employees from all four Anglo American operations attending the OHS representative training averaged not more than 13.12% (Anglo American, 2016).

Table 5.1 Employment in the MMS and MMS employees entering OHS skills programme

Year	Employment in the MMS sector in SA	Employees entering MQA OHS representatives skills programme	Percentage of MQA employees entering OHS representatives skills programme	Employees Completing MQA OHS representatives skills programme	Percentage of MQA employees completing OHS representatives skills programme
2013	572518	6438	1.1%	1068	0.2%
2014	575768	4694	0.8%	4339	0.8%
2015	525248	6000	1.1%	4519	0.9%
2016	520003	6200	1.2%	6000	1.2%
2017	550905	6500	1.2%	6200	1.1%
2018	493471	6500	1.3%	6000	1.2%

(MQA, 2019)

Current research (Passmore et al., 2015; Mabika, 2018) indicates that training improves workplace safety and health and offers some potential in helping support learning and behaviour change to reduce injuries and fatalities in the mines. Freitas and Silva (2017) and Zhang et al. (2016) emphasising that safety and health training is vital to reduce injuries and fatalities in the mines and to be effective such training needs to be continuous and must also be transferred to the job.

The MQA is a public entity established in terms of Section 45 of the Mine Health and Safety Act (MHSA) 29 of 1996 and is regarded as a Sector Education and Training Authority (SETA) in terms of the Skills Development Act 97 of 1998 (SDA). A mandate given to the SETAs is to facilitate the delivery of sector specific skills interventions that help achieve the goals of the National Skills Development Strategy (NSDS) which was since replaced by NSDP. In the financial year 2018/19, the MQA trained 9001 employees in health and safety in SA mines, and only relating to one course (Occupational and Health Programme) on health and safety representative activities. This number seems insufficient in relation to size of the industry but also questionable is the fitness to purpose of these health and safety programmes to flatten the curve of injurious, fatalities and work related diseases. Rupprecht (2015) indicated that while training is an integral part of risk management in mines in line with MHSA, the limited number of employees trained annually on health and safety by the MQA hampers employee ability to effectively participate in OHS matters in the MMS.

According to Mabika (2018), improving worker safety in mining especially through skills development and training is critical. This is in line with Walker (2014), who suggested that lack of knowledge and training is a major cause of occupational accidents especially in the mining sector. This requires the MQA to come up with educational programmes that can enhance employee skills and improve hazard avoidance, injuries and fatalities in mines (Carter, 2016). Workers would be safer when properly equipped with the tools and knowledge to use when faced emergency. Though the MHSA require mine owners to ensure that miners are adequately trained on health and safety issues, many mines still do not have adequate training systems to deal with health and safety issues (Anger et al., 2015; Walters et al., 2016).

Table 5.2 shows that OHS representative development budget constitute only 1.4% of the MQA annual budget in 2018. This is down from 3 per cent in 2013/14 financial year. While the MQA has the responsibility to develop skills in other areas in the MMS, its core mandate is in OHS, yet OHS training still constitutes a small proportion of its annual budget.

Table 5.2 MQA budget and OHS Representatives development budget

Year	**MQA budget R000**	**OHS REPS development budget R000**	**OHS REPS development budget R000 as a % of MQA budget**
2013/14	383425	11492	3.0%
2014/15	714378	12498	1.7%
2015/16	812118	14108	1.7%
2016/17	1151530	15000	1.3%
2017/18	1208918	16050	1.3%
2018/19	1269364	17174	1.4%
2019/20	1340448	18376	1.4%

(MQA, 2019)

Although the MQA has developed content in a variety of mine worker competence including safety and health, literature points out that there are existing limitations in various areas on health and safety including competencies in self-escape, emergency response among other areas (Ivensky, 2016). Following this, Mabika (2018) concluded that the safe operation of a mine is dependent on the competence of the employees. This is supported by research that points to the fact employee training and participation, timely maintenance in the MMS are more important accident prevention factors than risk assessment and preventive OSH services (Yilmaz & Alp, 2016).

5.5 FACTORS INFLUENCING THE EFFECTIVENESS OF EDUCATIONAL AND OHS TRAINING INTERVENTIONS IN THE MMS

The challenge of accessing training databases in mines is the fact that OHS training in the MMS is diverse, non-standard and largely unregulated despite the existence of legislation (Tuchten, 2011) and institutional support systems provided by MQA. There are no training guidelines such as the voluntary guides produced by OSHA in the USA and the Government of NSW, Australia. It is therefore difficult to assess the effectiveness of OHS training programmes in the MMS with limited information and standards.

It is also difficult to evaluate the effects of OHS training separate from other workplace considerations especially if outcomes such as work-related injuries and illnesses are used as measures. Occupational health and safety training are nested in other employer programmes that are affected by numerous extra or post training factors and interactions therefore complicate efforts to assess training-specific impacts on health and safety or productivity performance measures (Cohen & Colligan, 1998). The success of training programmes in enhancing worker knowledge and control of workplace hazards and ensuring conformance with safe work practices depend greatly on extra-training or post-training environmental factors including management's role and actions in favouring conditions which enable the knowledge gained from training or learned behaviours to be readily transferred to the jobsite.

5.5.1 Elements of an effective OHS educational and training programme

Authoritative literature reviews of general and job-specific OHS training have emphasised the importance of specific elements as critical to an effective OHS training programme including: (1) conducting a needs assessment, (2) Establishing training objectives, (3) specifying training content and methods, (4) accounting for individual difference, (5) specifying learning conditions, (6) evaluating training and, (7) reviewing and revising training (Cohen & Colligan, 1998).

5.5.1.1 Needs assessment

According to these researchers, training goals presuppose: (1) consistency with organisational goals; (2) the presence of jobs designed to yield performance outputs that meet the organisation's goals, and (3) performance levels dependent on knowledge of the job tasks, skill, attentiveness to the work or factors where training can make a difference. Job analyses determine which of the relevant performance factors comprise the highest priority training needs either now or in the future. The process includes defining the tasks involved, their order of importance (in terms of frequency, criticality, complexity), and details of the steps necessary to accomplish them.

Training on safety and health practices is provided to all employees and contractors at induction training when joining the Company and when returning from annual leave. Legal and risk-based health and safety training is planned and conducted based on operational training needs. The importance of safety and the prior day's safety performance are communicated daily to sustain awareness. Safety performance forms part of incentive schemes at operational level (Lonmin, 2017).

5.5.1.2 Establishing training objectives

The needs assessment provides the information to establish the objectives of the training programme. These are stated as observable behaviours expected of the trainee after the instruction, and they may acknowledge the conditions under which they should be performed and the required level of proficiency.

5.5.1.3 Specifying training content and media

Content represents the knowledge or skill that the trainee must master to be able to meet the behavioural objectives. The judgement of those who know the job demands is the most common approach to specifying training contents. Other approaches may be the products of problem-solving exercises or be based on mistakes people make in using a skill such as to design corrective learning measures (Cohen & Colligan, 1998).

5.5.1.4 Accounting for individual differences

The researchers suggest that effective training should take account of the characteristics or attributes of the trainees. Aside from differences in aptitude, literacy, or pre-training skill levels, how trainees view the training programme in terms of improving their job performance or self-efficacy may dictate variable approaches. The kind and level of training for new job applicants versus long-term or older workers reassigned to the same tasks also has to be addressed.

5.5.1.5 Specifying learning conditions

In general, instructional events comprising the training method should not inhibit, conflict with, or be unrelated to the processes that lead to mastery. If the learning is to develop capabilities in problem-solving techniques, the instructional approach should stress thinking/reasoning approaches not rote memorisation. Training methods should require the trainee to use the training content in active or productive ways, e.g., restating or applying principles rather than just recalling them, or adapting the information to new situations rather than mere repetition in the same one. The current literature suggests that using learning events that require productive behaviour or that provide appropriate feedback (positive/accurate/credible) and opportunities for practice under conditions that promote transfer to the actual job are ideal.

5.5.1.6 Evaluating the training

OHS research has also focused on the criteria for rating the effects of OHS training. They indicate that most in-house training programmes are assessed by measuring only trainee reactions of how well they liked the instruction but the extent to which the training content was absorbed or resulted in changes in actual on-the-job behaviours or impacted organisational measures is rarely determined. In addition, trainee reactions to instruction may bear little relationship to the extent of actual learning and should not be used as the sole criterion for gauging effectiveness, while pre- and post-training quizzes or tests of skill to show gains from instruction may or may not be related to on-the-job performance thus requiring multiple measures of effectiveness. Other workplace factors affect training in both training and post-training environments and their influence on training outcome have to be accounted for (Cohen & Colligan, 1998).

These researchers further point out that using simple performance measures representing various levels of achievement may be critical for determining the validity of instruction but may not indicate the factors that influenced these results. Hence, process measures including training time, modes of training, trainer attitude and competency can provide an indication why overall results were or were not achieved and training can be revised to improve efficacy. Gaps or variations in knowledge or competencies resulting from the training may reflect needs to consider more training time, alternative instructional techniques, or more capable instructors.

5.5.1.7 Revising the training

Gaps or variations in knowledge or competencies resulting from the training may reflect needs to consider more training time, alternative instructional techniques, or more capable instructors.

5.6 FACTORS TO BE CONSIDERED IN DESIGNING TRAINING OR EDUCATIONAL PROGRAMME FOR UNDERSERVED WORKERS

The literature review found an approach to education and training for underserved workers in the United States of America that is relevant to the situation in the South African MMS dominated by a racial divide. Underserved workers are defined as many low-wage workers native or migrant who have limited formal education. These workers may have limited literacy in their native language, as well as in English (O'Connor et al., 2014). This is pertinent to the characteristics of the workforce in the South African MMS. This research suggests the following factors to be considered when designing an OHS training or educational programme for underserved workers.

5.6.1 The primary purpose of the programme

The primary purpose of the programme affects the choice of methods and appropriate evaluation approaches and metrics and should therefore be identified and clearly stated. Hence the primary purpose of the programme may be to focus on: knowledge transfer/skills development, e.g. a programme to teach workers about chemical hazards in their work environment and the associated warning signs and labels; attitudinal change, e.g., a programme geared towards increasing workers' degree of concern about safety and health hazards in the workplace or enhancing the extent to which they believe that it is possible to reduce their exposure to such hazards by taking certain actions); or empowerment (social action), e.g., a programme designed to encourage workers to talk with each other about job hazards and to take collective action to solve problems (O'Connor et al., 2014). The researchers suggest that practically most good training programmes involve a combination of the three.

5.6.2 The context for the training programme

Immigrants and English-language learners often identify more strongly with community-based organisations that communicate in the same language and reflect their cultural practices, and that they see as representing their community more than an employer or union representatives can. Health and safety training programmes need to adapt to the very different work contexts of these groups of workers and recognise the many barriers that trainees face in putting into action lessons learned from training programme. Unionized workers with stable employment feel more secure in their jobs, have more opportunity for input into decisions affecting their working conditions, and are more likely to have the benefit of paid time for safety and health training. Temporary and contractual workers have high levels of job insecurity and have little influence on decision-making affecting their working conditions. Undocumented immigrant workers are fearful not only of speaking up for their safety and health rights but of the spectre of deportation if they come into conflict with their employer.

5.6.3 The type of training approach selected for the programme

OSH education and training programmes use a variety of approaches to reach their target audiences, particularly underserved populations of workers including public health/social marketing campaigns; train-the-trainer programmes; lay health advisor programmes; and direct worker training. The choice of approach is often based on practical factors such as availability of funding and access to the target populations.

Public health campaigns/social marketing programmes are used in addition to direct training of workers through their workplace or community. Governmental and nongovernmental agencies reach workers and their families with public health messages or social marketing campaigns addressing issues such as lead-based paint exposures to residential painters; introducing OHS themes into existing popular media, e.g. a government agency collaborated with a team of OSH experts and a team of a popular Spanish language telenovel*a* (soap opera) to introduce construction safety messages designed to reach Latino construction workers and their families.

Train-the-Trainer Programmes are designed to train trusted individuals in a community or workplace, who then receive ongoing support to provide training and education to their peers. This approach is based on the understanding that people are most receptive to messages from people who they perceive to be like themselves. Several national unions in the USA have developed very successful, long-term programmes that have provided training to hundreds of “worker-trainers,” who have, in turn, trained thousands of their fellow employees. To become successful trainers, trainees must receive intensive follow-up, coaching, and resources. An example for OHS practice in the South African MMS could be the training of trainers selected from among the mining workforce to deliver the Health and safety Representative Course developed by the MQA.

The effectiveness of peer educators as writers of curricula, leaders of train-the-trainer programmes, and evaluators has been documented as well as programme impacts such as participants having confidence and a willingness to make workplace health and safety improvements following the training, use of training materials as resources, and increased communication between workers and managers (O’Connor et al., 2014).

The vast majority of OSH training and education programmes involve training workers directly, whether in the workplace, union hall, or community. Such training may range from brief interactions with workers on the street to highly structured, long-term training programmes.

5.6.4 The training delivery methods

In the last three decades, the field of OSH training has developed a range of creative, engaging training methods, many of which are guided by the principles of Popular Education, an approach that emphasises active roles of training participants in analysing problems and developing practical solutions. Popular Education focuses attention on the power dynamics that affect participants’ abilities to effect change in their lives and seeks to develop participants’ critical thinking skills and confidence as actors in improving their conditions. In place of the traditional instructor-to-student learning model, Popular Education emphasises the importance of student-to-student and student-to-instructor learning. For example, occupational health training by unions and community organisations adapted these Popular Education methods in an effort to make small group learning participatory within specific employment and enforcement contexts. The Oil, Chemical and Atomic Workers Union developed a small group activity method to conduct hazardous materials training.

Burke et al. (2006) cited Hlatywayo and Nel (2013) found that as training methods become more engaging (that is, requiring trainees’ active participation), workers demonstrate greater knowledge acquisition leading to reductions in accidents, illnesses, and injuries. Chaves et al. (2009) cited Hlatywayo and Nel (2013) showed that the degree of implementation is associated with the employees' level of health/safety knowledge and training and communication between the occupational safety and the health team. These findings remain unchanged after adjustment for levels of education among managers and employees.

Popular Education methods applied in OSH training have been demonstrated to be more engaging and effective. A comprehensive review found that more engaging training methods such as simulations and hands-on exercises and storytelling were more effective in terms of knowledge acquisition and reduction of negative outcomes than less engaging methods, such as lectures. Hands-on exercises and simulations require learners to apply knowledge gained in real-life situations and can be used to practice relatively simple tasks, such as fit-testing a respirator, or for more complex operations, such as putting into practice an emergency response plan for a hazardous chemical release (O'Connor et al., 2014).

Storytelling is another creative method of training that can be a powerful learning tool. Many workers in highly hazardous trades learn job- and safety-related skills and information more from their peers than from professional trainers. A study of the use of storytelling as a training technique among mineworkers argues that one of the most compelling methods of getting young miners' attention is to have experienced miners tell them stories of workplace disasters that led to deaths and injuries of friends and co-workers (O'Connor, 2014).

5.6.5 The process of determining training content

Researchers suggest basic guiding principles when determining training content for programmes designed to reach underserved workers: Include information about workers' rights under relevant laws and regulations; encourage collective rather than individual action to address OHS problems so as to reduce exposure of vulnerable workers to retaliation; pose problems and create a forum for workers to analyse them collectively and encourage workers to consider short-term steps towards improving OHS conditions where more aggressive action by workers may invite employer retaliation. Further, training that provides leadership skills for organising and taking action is likely to be more effective in achieving positive changes than training that simply transmits knowledge or teach skills. Leadership skills training are more likely to address the very real and powerful structural barriers to improving OHS conditions among underserved workers (O'Connor et al., 2014).

A pertinent case study is training attended and described by Dr Phakathi in a South African gold mine in 2010 known as the ***Great Noligwa Mine supervisory training programme 2007*** (source: Phakathi, 2010).

The researcher, Dr Phakathi, was a participant in the training programme for mine supervisors and wrote a test on the topics they had learned over three days. The researcher identified positive as well as negative aspects in the design and implementation of the course. The organisation was commended for recognising supervisors as change agents in the mine and the course was both informative and interactive. However, the planning of the course content was top-down as most discussions on operational issues reflected the perspectives of top managers and revealed a divergence between what supervisors were told and what really happened on the frontlines underground, especially the significance of the informal organisation of work through the gold miners' underground practice of making a plan (planisa) to execute tasks. Work relations between supervisors and their superiors were to a large extent overlooked with important organisational issues such as materials and labour shortages and poor production coordination not mentioned. Underground work teams were not included in the training, hampering effective implementation of the materials learned. It did not make use of the subjective, day-to-day work experiences and practical knowledge of the shift-boss, stope team leaders and production crews.

5.6.6 Social and cultural factors

When planning a training programme for underserved workers including migrants, there is need to take into account social and cultural factors including literacy, language, and cultural appropriateness of materials that can influence the effectiveness of training among the population targeted. Literature review identified some strategies that can be used to ensure training and materials are appropriate to the culture of the target audience including the necessity to involve members of the target audience in the design and development of training materials or conduct a focus group test of the materials with the target audience; Graphics should be relevant to the target audience, e.g. cartoon characters or photos used should depict members of the target audience; understand cultural values and beliefs that may affect behaviour (O'Connor et al., 2014).

5.6.7 Literacy issues

Many low-wage workers native or migrant have limited formal education. These workers may have limited literacy in their native language, as well as in English, hence it is essential for trainers not to rely too heavily on written or text-dense materials when delivering training to this category of workers. Written materials should use relatively few words, clear pictures, bulleted key points, and ample white space. Experts have suggested the use of strategies including conducting needs assessment to understand literacy levels of trainees; refraining from calling on trainees to interpret charts or graphs, rather reading materials out loud or soliciting volunteers; using participatory activities (mapping, games or quizzes) instead of asking trainees to read materials; Field-testing of all training materials with the intended audience to ensure their appropriateness; respecting the wealth of skills and knowledge that trainees with limited literacy bring to issues. Workers with limited literacy are a valuable reservoir of knowledge and wisdom about how to confront OHS challenges at work despite some specific weaknesses in formal learning environments (O'Connor et al., 2014).

5.7 DEALING WITH RETIRED/RETRENCHED AND AN AGEING MINE WORKFORCE AND INFLUX OF NEW AND YOUNG MINERS

5.7.1 Dealing with retrenched, ageing and young workers

MQA (2018) noted that downscaling and closing of operations in the MMS due to globalisation of markets lead to retrenchment of mine workers needing new jobs. In addition, the mine workforce is ageing, and replacements are young. The challenge is to re-skill or up-skill these retrenched mineworkers to enable gain access to the job market as well to develop skills for new entrants to cope with changing technology and work environment.

In the US, NIOSH (2002) determined as a major concern in the mining industry how to train both an ageing workforce and the expected influx of new miners and mine managers as older workers retire and that, based on this reality, the principles of adult learning and systems approach have become fundamental to the delivery of effective training in the mining industry. According to NIOSH (2000), new miners may be young people who lack the ability to recognise and respond to mining hazards in an appropriate manner and may also have had different educational experiences than their older counterparts, necessitating different approaches to training for both cohorts.

NIOSH (2002) argues that miners have deep respect for experts in their field and, therefore, using the “mentor-protégé” model for teaching miners in which expert miners become mentors to other workers will in this way fashion out training programmes that have legitimacy and credibility that resonate with trainees. For example, mine trainers can use this method to develop their own toolbox training to refresh knowledge and skills and to communicate new hazards specific to a given mine site instead of attempting to use generic information, cover a broad subject or teach a new skill during the 10-15 minutes available for the training.

5.7.2 Best practices (dealing with people with special needs (disability)

There is little focus in South African literature on the issue of training workers with special needs (with disability).The review of literature identified some best practices when planning and delivering training to miners with limited English proficiency or non-English speaking, little or no literacy and miners with special needs (disability). According to System-wide Training and Education Workgroup (2011) health, safety and environment training best practice standards and guidelines:

- For miners with limited English language proficiency, materials should be easy to understand, simplified or written in local languages, materials should encourage interaction, participant input and critical thinking. Pictograms, visuals, demonstrations and other non-verbal methods should be used to convey messages and partner them with participants who can help.
- For low-literacy level miners, low-literacy training materials and teaching methods should be visual in nature and not limited to written communication. Teaching methods should require fewer literacy skills (photos, short role-plays, case studies, demonstrations, hands-on practice, and small group activities). Use simple and short sentences and present one topic at a time.
- For non-English speaking miners, communicating and providing materials in the native language of participants including use of interpreters will achieve best outcomes.
- For individuals with an inability to perform some or all of the tasks of daily life, they may require modifications or adjustments that make it easier or possible for them to participate in the same manner as other employees. This category of miners

may have special needs such as challenges with learning, communication, emotional and behavioural disorders, physical disabilities, and developmental disorders. These individuals can be accommodated by implementing appropriate modifications to the lesson plan (i.e., skipping subjects, simplified assessments, shorter assignments, extra aids, and extended time, skipping material inappropriate for the individual's abilities, or teaching less information than typical participants, implementing shorter assignments, such as a test with 10 questions instead of 50). Provide a list of words during tests to reduce lack of recall and allow them to benefit from offering extended time to recall information or complete training tasks.

5.8 DEVELOPMENT AND USE OF VOLUNTARY TRAINING GUIDES

In Australia, Government Agencies develop training modules to guide company trainers in developing their training materials to meet legislative and regulatory requirements, e.g. the Occupational Health and Safety Guide for Cleaning and Property services industry; WorkCover Workplace health and safety training resource kit Funded under the Workplace English Language and Literacy (WELL) Programme by the Commonwealth of Australia through the Department of Education Science and Training (DEST). The kit provides guidelines for topics such as Health and safety law, health and hygiene, recognising workplace hazards, manual handling, hazardous substances, noise in the workplace, etc. These guides are designed to improve in-house training in OHS (WorkCover, 2002).

5.9 OCCUPATIONAL HEALTH AND SAFETY SKILLS SHORTAGES AND SKILLS GAPS

5.9.1 General aspects of Skills development in the MMS

Qualifications describe the employability skills, problem solving, communication skills and whether a person is a team worker. Providing skills to previously underprivileged group is a significant long-term success to the mining transformation. Most black people were not exposed to any kind of training during the apartheid government; they lack the experience and necessary skills to occupy executive positions. Therefore, obtaining proper qualifications will contribute towards improving safety and efficiency in the sector; as well as providing opportunities for historical disadvantaged individuals to gain skills and procure necessary qualifications so that mine enterprises can "attract and retain suitable employees" (Ntsuxeko, 2017).

Employers are obliged to come up with the safety measures and make sure that all workers are protected and not exposed to hazardous environment. Thus, mining industries have established external training courses to offer a service to certain mining sectors and most of these courses have received official accreditation nation-wide, as well as state organisations. Some industries also arrange for in-house training by delegating some of their own workers as mentors or making use of professional instructors. In-house training is the most prominent method that grants the managing board and workers an opportunity to learn new things and sharing of service delivery in the industry (Ntsuxeko, 2017).

Everyone working at the site must be competent for the work they are required to execute or be supervised by competent workers. They, and their managers, need to know the limits of their competence (WorkSafe New Zealand, 2015). According to WorkSafe, the competencies needed for a particular job can be determined through the risk assessment and hazard identification processes; personal information review; health and safety audits or inspections; analysis of accident investigations and near-miss reports; competencies specified by vehicle or equipment manufacturers; National qualifications framework; recommendations in Codes of Practice, Guidelines or Standards, and those required by the law. Managers can compare competencies needed with those which people already have to determine what additional skills are required and how these can be achieved, for example by way of training and coaching or mentoring.

"Mine workers who do not require a certificate of competence or who have not achieved unit standards specified by WorkSafe must be accompanied (supervised) at all times by a mine worker who has achieved the unit standards, or has received equivalent training, or holds a certificate of competence, and has at least 12 months experience working at the same kind of mining operation".

Section 17 of Coal Mining Safety and Health Act 1999 requires the appointment of electrical engineers with necessary qualifications to manage and control any mine electrical work. Such qualifications are obtainable at specialised technical institutions. For example, Mining Education Australia provides diverse mining engineering courses to undergraduates. Through the studies the students gain detailed skills and knowledge regarding the operation of mining industry (Ntsuxeko, 2017).

MQA research identified the top 10 hard-to-fill vacancies in the MMS and determined the reasons for the situation including lack of skills, relevant qualifications, experience, high salary expectations and lack of career awareness at the level of the individual; at the level of the organisation, lack of competitive compensation structures to attract potential employees, lack of succession planning and knowledge about career options (MQA, 2018).

The Skills Development Act defines a skills programme as: A unit standard based programme that is occupationally based; a National Qualification Framework (NQF) aligned programme presented by an accredited training provider; and a programme, when completed, constitutes credits towards a qualification registered on the NQF.

The key elements of a Skills Programme include total credit value must not be less than 120 credits; must be unit standards based; must have a structured workplace learning component; and Employers or training providers may develop skills programmes. However, the skills programme must be registered with the relevant Quality Assurance (QA) authority. In the case of the MMS, this authority is the MQA.

The purpose of a skills programme is to: provide learners with practical (hands-on) experience where appropriate; increase employability, self-employment and mobility in the workplace; provide occupationally directed and focused learning; contribute towards closing the gaps identified in the Workplace Skills Plan (WSP), Sector Skills Plan (SSP) and Provincial Skills Plan (PSP) or research; advance career aspirators of employees; and address the principles of portability, access redress and equity in the workplace.

Criteria to determine the need for a skills programme comprise: there must be assurance that there is a need for that programme in the sector before a skills programme is registered within the MQA. The criteria for proposing a skills programme are based on the following: estimated number of learners that may benefit from the skills programme; the skills needs to be addressed; the criticality or scarcity of the skills to be addressed; the structured learning component; the availability of employers as well as qualified personnel to provide coaching and mentoring if required; and the availability of accredited training providers and registered assessors.

Examples of MQA skills programmes, among others, include Skills programme in Occupational Health and Safety activities for: Part Time/Workplace Representatives and shop stewards in the mining and minerals sector; Competent Person B skills programmes for underground coal mining operations, etc. The MQA identified re-skilling of retrenched workers as an area that requires attention from a skills development perspective to facilitate their absorption into other sectors of the formal labour market and entrepreneurship endeavours (MQA, 2018).

According to AngloGold Ashanti, the organisation supports the development of skills across its operations and in the communities in which the company operates providing accredited technical training in mining, mining services, engineering, metallurgy as well as training related to occupational environment, safety and health. The company also supports work exposure and vacation and graduate training. At South Deep, there has been a particular focus on the development of mechanised mining skills, of which there is a shortage in South Africa. As part of this programme, South Deep employees regularly visit the Group’s modern Australian mines, teaming up with their counterparts at these operations (Anglo American, 2016).

The MQA Health and Safety representative course is a skills programme and mine workers credited with it are able to represent employees on all aspects of occupational health and safety, thereby exercising their rights and powers in terms of Mine Health and Safety Act (Act 29 of 1996) Section 30 to identify and report on potential hazards and risks associated to occupational health or safety. The rationale of this training emphasises compliance and it does not set specific objectives against which the effectiveness can be measured including a lack of provision for evaluation and review of the programme. Anglo American indicated in their 2016 annual report an average of 13.12% attendance from all four operations in South Africa (Anglo American, 2016).

Anglo American (2016) reported rewarding results from efforts to attract, develop and retain talent through a greater focus on developing skills through on-the-job training, which is more cost-effective than external training (Anglo-American, 2016). According to this company, all employees and contractors receive appropriate health and safety training, and several attend their SHE risk-management training programme, while individual non-compliance with correct use of personal protective equipment (PPE) remains a challenge. This annual report has an indication of cost-effectiveness but none on the effectiveness of these programmes.

5.9.2 Occupational health and safety skills shortages and skills gaps

5.9.2.1 Hard to fill vacancies in the MMS

According to the MQA (2019), Hard-to-fill occupations refer to occupations which employers struggle to find candidates for a sustained period of 6 to 12 months. These vacancies are identified by employers including the reason(s) for the scarcity. The MQA sector skills plan (2019) lists the top 10 hard to fill skills in the MMS and are shown in Table 5.3.

Table 5.3 Hard to fill vacancies in the MMS (source: MQA Weighted WSP/ATR (31 May 2018))

Occupation name	OFO Code	Reasons
Engineering Manager	2017-132104	• Lack of relevant experience • Lack of relevant qualifications
Mining Operations Manager	2017-132201	• Lack of relevant experience • Lack of relevant qualifications
Mining Engineer	2017-214601	• Lack of relevant qualifications
Safety, Health, Environment and Quality (SHE&Q) Practitioner	2017-226302	• Lack of relevant experience • Lack of relevant qualifications

Occupation name	OFO Code	Reasons
Mining Production Supervisor	2017-312101	• Lack of relevant experience • Lack of relevant qualifications
Engineering Supervisor	2017-312103	• Lack of relevant qualifications
Rigger	2017-651501	• Lack of relevant experience • Lack of relevant qualifications • Unsuitable job location
Boiler Maker	2017-651302	• Lack of relevant experience • Lack of relevant qualifications
Diesel Mechanic	2017-653306	• Lack of relevant qualifications
Millwright	2017-671202	• Lack of relevant experience

(MQA, 2019)

Table 5.3 shows that OHS in the MMS remains a hard to find skill for two main reasons, lack of qualification and lack of experience. In the financial year 2017, companies in the MMS sector identified over 132 vacancies in the OHS that were hard to fill (MQA, 2019). This situation is a serious concern as the persistence of such vacancy rate can result in more mine accidents and fatalities, making it harder to reach the zero harm targets.

5.9.2.2 OHS Skills gaps in the MMS

Generally, skills gaps refer to lack of skills or deficiencies in employees or the absence of specific competencies in employees to undertake a job tasks successfully to required industry standards (MQA, 2019). In the context of OHS practice in the MMS, skills gaps will refer to the lack of skills or competencies in employees to identity and deal with OHS issues to ensure a safe work environment for all. Skills gaps may arise due to lack of training, new job tasks, technological changes, or new production processes. According to the DHEST, the term "top up skills" also refers to skills gaps. It usually requires a short training intervention (DHEST, 2017). OHS experts as identified are in short supply, particularly skills in MHSA, 1996 and Regulations, risk management process, communication and OHS.

In the MMS there is a need for both general skills in OHS and more specific skills for different types of employees as they perform different roles. Most of these skills are acquired through formal and informal training and skills transfers (This is Gold, 2018). This section focuses on skills supply in OHS based on an analysis of information from SAQA, DHEST, the MQA, and other relevant institutions.

Findings revealed that the most common skills gaps according to industry experts for senior managers are related to leadership and managerial skills, whilst technicians and artisans experience skills gaps in people, supervisory and communication skills as well as knowledge and application of new technology. Managers are expected to understand the process of influencing staff members and agreements should be made on factors that impact the facilitation of processes that influence individual and collective efforts to accomplish shared objectives. On the other hand, lower-level employees, i.e. plant operators and elementary workers lack computer and numeracy skills. Knowledge and ability to utilise computers and related technology specific to areas of work is imperative for the development of these employees in the sector (MQA, 2019).

The South African Qualifications Authority currently has 18779 qualifications registered as at the 14th/11/2019. Out of these qualifications 12 (0.006%) are related to courses that can improve OHS as shown in Table 5.4. However, some of the risk management courses identified are generic and not specific to OHS in the MMS sector. There is surprisingly no registered course dealing with occupational diseases in the MMS. This is despite the fact that occupational diseases continue to impact on the health of workers and also on the productivity of the sector. In order to deal with OHS issues in the MMS sector, there is need to have a targeted and comprehensive skills development qualifications that are registered with SAQA and can be implemented in the sector to reduce mine accidents and fatalities. Most mines implement separate OHS education and training programmes that are not generally accessible (This is Gold, 2018).

Table 5.4 Qualifications registered with SAQA Related to OHS in the MMS

NQF sub-framework	Qual ID	Qualification title	NQF level
HEQSF	16098	Diploma: Mine Health and Safety	Level N/A: Pre-2009 was L5
HEQSF	16094	Certificate: Mine Health and Safety	Level N/A: Pre-2009 was L5
OQSF	99714	Occupational Certificate: Safety, Health and Quality Practitioner (Occupational Health and Safety Practitioner)	NQF Level 05
HEQSF	102423	Advanced Certificate in Business Management in Risk Management	NQF Level 06
HEQSF	15156	Bachelor of Commerce Honours: Information Risk Management	NQF Level 08
HEQSF	16936	Bachelor of Commerce: Risk Management	Level N/A: Pre-2009 was L6
HEQSF	111116	Bachelor of Science in Quantitative Risk Management	NQF Level 07
HEQSF	58012	National Certificate: Disaster Risk Management	NQF Level 07
HEQSF	99718	Postgraduate Diploma in Disaster Risk Management	NQF Level 08
OQSF	64870	Further Education and Training Certificate: Generic Management: Disaster Risk Management	NQF Level 04
OQSF	57613	Further Education and Training Certificate: Short-Term Risk Management	NQF Level 04
OQSF	24396	National Certificate: Risk Management	NQF Level 04

(SAQA, 2019)

According to our analysis of the SAQA databases, out of the 15,799-unit standards registered with SAQA, there were ten identified to be related to OHS in the MMS as shown in Table 5.5. These statistics still point to the fact that there is a need to continue to develop comprehensive unit standards or occupationally linked modules that can deal with more specific issues of health and safety in the MMS.

Table 5.5 Unit standards registered with SAQA that relates to OHS in the MMS

Org Field	Subfield	Originator	US ID	Unit standard title	NQF level
6	Fabrication and Extraction	SGB MM	110205	Demonstrate knowledge of the Mine Health and Safety Act, regulations and definitions	NQF Level 02
6	Fabrication and Extraction	TT 6 F&E	336939	Demonstrate an understanding of the mine health and safety Act, for small-scale mining	NQF Level 04
3	Human Resources	SGB HRMP	119926	Apply the Occupational Health and Safety Act and the Mine Health and Safety Act in mediation	Level TBA: Pre-2009 was L5
11	Cleaning, Domestic, Hiring, Property and Rescue Services	SGB F&R	243317	Facilitate, guide and advise the process of adopting integrated disaster risk management policies and systems	Level TBA: Pre-2009 was L7
11	Cleaning, Domestic, Hiring, Property and Rescue Services	SGB F&R	243321	Manage communications for effective disaster risk management practices	Level TBA: Pre-2009 was L7
11	Transport, Operations and Logistics	SGB T&LO	123190	Design and implement a risk management control system	Level TBA: Pre-2009 was L5
3	Finance, Economics and Accounting	SGB FinS	14996	Apply the mines and Works Act, 27 of 1956 (as amended) as it impacts on risk management to a specific operation	NQF Level 04
3	Finance, Economics and Accounting	SGB FinS	15007	Demonstrate knowledge and understanding of South African law and the regulation of risk management	NQF Level 04
3	Finance, Economics and Accounting	SGB FinS	14992	Demonstrate knowledge and understanding of the Explosives Act, 26 of 1956 as amended as it impacts on risk management	NQF Level 04
3	Finance, Economics and Accounting	SGB I & I	117149	Apply knowledge and insight into the statutory cover afforded under the Compensation for Occupational Injuries and Diseases Act, 130 of 1993, as amended (COIDA)	NQF Level 04

(SAQA, 2019)

A review of the MQA intervention in terms of bursaries, internships/learner ships, and also qualifications offered by TVETs and other institutions of higher learning showed that OHS in the MMS remains at the periphery of resource allocation and structured courses or programmes. Skills areas which need improvement in the MMS include mathematics and science, career awareness, practical training and work integrated learning (WIL), work experience, Government certificate of competency, management skills, shortage of trainers, and youth apathy (MQA, 2019).

5.9.3 Recruitment and OHS training of supervisors

The literature review identified a current issue in OHS practice relating to the recruitment and OHS training of supervisors. South African researcher, Dr Phakathi (2010) found deficiencies in the training programme designed for supervisors in a gold mining company. A study across the UK Oil and Gas industry found that more than half of the organisations in the sample had no systems in place to provide coaching and mentoring of supervisors, while less than 50% had formal behavioural standards (Petrie, 2014). A study commissioned by the HSE (2003); *"RR156, Causal factors in construction accidents"*, found little evidence of any health and safety education for those at supervisory levels within the study.

The study found gaps within a number of processes for selecting, training and developing behaviour models for supervisors. However, a small number of organisations had very effective processes for the development of supervisor safety behaviours. For example, some organisations had recruitment processes using multiple methods that included leadership behaviours, one drilling company trained supervisors to a high standard (NEBOSH certificate level) and other organisations had fully developed behaviour model for supervision (Petrie, 2014).

"The bulk of all training hours in the industry is applied to safety training, both in specific training modules and on-the-job. All employees are exposed to safety training in induction and refresher training on at least an annual basis. Both full-time elected safety stewards and part-time safety representatives are allocated to each working area underground, with safety briefings at the beginning of every working shift" (This is Gold, 2018). There is a necessity to explore the requirements for developing a skills training programme for supervisors at all levels in the MMS.

5.10 SUMMARY OF FINDINGS AND IMPLICATIONS FOR THE STUDY

The review showed that the MHSA 1996 governs OHS practice in the MMS and sets the tone for education and training of employees to enable them to perform their work safely and without risk to their health. Three approaches characterise OHS training in the MMS: training of workers in a way that combines self-protection with risk avoidance to fellow workers and others; designing and delivering induction and refresher training to all ranks of mine officials on issues relating to the greatest risks to health and safety and, using Adult Basic Education (ABET) as a primary intervention for health and safety in the MMS.

Focusing on change drivers shaping skills development in the MMS, the review found that the integration of advanced technology in the mining process is transforming the skills demand within MMS, placing a new demand on the type, level and mix of skills and qualifications required by the sector. Empirical studies confirmed that improved technology reduces underground mining accidents. They suggest, however, that new technology may come with new hazards and these require specialised skills to recognise and deal with them.

Key drivers such as enterprise development impact on job creation and community unrests and the impact of HIV/AIDS create a loss of key skills and replacement costs. The need for energy and water efficiency, as well as the reduction of pollution creates corresponding need for skilled workers. Further, downscaling and closing of operations in the MMS due to globalisation of markets lead to retrenchment of mine workers needing new jobs and re-skilling or up-skilling of those retrenched with skills to enable them gain access to the job market. Also, current South African legislative instruments promote opportunities leading to transformation and career growth for the workforce in the MMS and this demands novel initiatives in skills development. There is a need to develop qualifications and learning programmes in the area of seismology. In addition, MQA will have to develop green skills to enable the MMS manage the environment sustainably.

We examined views on the impact of ABET on OHS performance in the MMS. ABET was derived from an assumption that low levels of formal education in the MMS negatively affect health and safety and would contribute to improving OHS performance through literacy, enhanced awareness and self-concept. However, there is paucity of research demonstrating the effects of under-education and its contribution to fatalities, injuries and ill-health.

Some research concluded that ABET improves safety in the workplace and that the higher the literacy levels, the better employees are able to interpret and understand safety requirements, thereby improving compliance and responses to risks. However, we found that the initial objectives and expected outcomes of ABET in relation to OHS practice and performance in mines against which the efficacy of the programme could be measured were not specified. There is no indication in literature of an association between ABET and reduction in accidents and occupational illnesses. We opine that one way of assessing the impact of increased literacy level on performance is by accident causal analysis.

We found evidence that the three focus areas of training required by the MHSA, 1996 originating from the Leon Commission (task or operator-specific training, ABET, and hazard-specific training) were not being addressed comprehensively with only task-specific interventions showing progress. Dedicated OHS training for mineworkers focussing specifically on problems that represent the greatest risk to health is limited. There was suggestion that the low showing of ABET is an indication that it is necessary to facilitate comparable awareness and mastery of health and safety subjects outside of ABET structures. We opine that an OHS awareness qualification module that can benefit employees in career progression may be in point. South African mining companies recognise the critical role education and training play in sustaining mining and invest in employee training and development through learnerships, bursaries, portable skills, internships and adult education.

Approximately 1% of the sector's employees have no schooling at all. This is a concern for the sector posing a risk to the sector skills development and the drive towards the zero harm milestones in the MMS. Between 2013 and 2018, only an average of 1% of MMS employees received OHS training annually, showing a huge deficiency in training expectations. For example, Employees from all four Anglo American operations attending the OHS representative training averaged not more than 13.12%.

In the financial year 2018/19, the MQA trained 9001 employees in health and safety in SA mines and it is suggested that the MQA should research and develop practical OHS educational and training programmes and guides for the MMS that can obtain stakeholder buy-in and be implemented to enhance employee skills in areas such as self-escape, emergency response to improve hazard avoidance, injuries and fatalities in mines. Several mines still do not have adequate training systems to deal with health and safety issues.

With regards to factors influencing the effectiveness of educational and OHS training interventions in the MMS, we found that OHS training in the MMS is diverse, non-standard and largely unregulated despite the existence of legislation, making it challenging to access training data bases in mines. It is also difficult to evaluate the effects of OHS training separate from other workplace considerations especially if outcomes such as work-related injuries and illnesses are used as measures.

Occupational health and safety training is nested in other employer programmes that are affected by numerous extra or post training factors and interactions therefore complicate efforts to assess training-specific impacts on health and safety or productivity performance measures. We found that the success of training programmes in enhancing worker knowledge and control of workplace hazards and ensuring conformance with safe work practices depend greatly on extra-training or post-training environmental factors including management's role and actions in favouring conditions which enable the knowledge gained from training or learned behaviours to be readily transferred to the jobsite.

Authoritative reviews emphasised the importance of specific elements as critical to an effective OHS training programme including: conducting a needs assessment to determine the knowledge and skills gaps; establishing training objectives against which training effectiveness and performance will be assessed; specifying training content including the competencies and skills and delivery methods; accounting for individual difference; specifying learning conditions; evaluating training and, reviewing and revising training.

The literature review found an approach to education and training for underserved workers in the United States of America that is relevant to the situation in the South African MMS dominated by a racial divide and a historically under-privileged population. Underserved workers are defined as many low-wage workers native or migrant who have limited formal education. These workers may have limited literacy in their native language, as well as in English. This is pertinent to the characteristics of the workforce in the South African MMS. This research suggests various factors to be considered when designing an OHS training or educational programme for that category of workforce.

We used the Great Noligwa Mine supervisory training programme to show that training content that is planned top-down will overlook issues at the bottom level and is less likely to achieve expected outcomes.

We found that increasingly retrenched mine workers need new jobs and in addition the mining workforce is ageing, and replacements are young. The challenge is to re-skill or up-skill these retrenches with skills to enable them gain access to the job market as well to develop skills for new entrants to cope with changing technology and work environment. New miners may be young people who lack the ability to recognise and respond to mining hazards in an appropriate manner and may also have had different educational experiences than their older counterparts, necessitating different approaches to training for both cohorts. The “mentor-protégé” model for teaching miners in which expert miners become mentors to other workers can be used and will in this way fashion out training programmes that have legitimacy and credibility that resonate with trainees.

There is little focus in South African literature on the issue of training workers with special needs (with disability).The review of literature identified some best practices when planning and delivering training to miners with limited English proficiency or non-English speaking, little or no literacy and miners with special needs (disability). For individuals with an inability to perform some or all of the tasks of daily life, they may require modifications or adjustments that make it easier or possible for them to participate in the same manner as other employees. These individuals can be accommodated by implementing appropriate modifications to the lesson plan.

We found international good practice in the development and dissemination of training modules and support guides for company trainers, for example, Work Cover (Western Australia) Workplace health and safety training resource kit which provides guidelines to improve in-house OHS training.

Reviewers analysed documents and literature relating to OHS skills shortages and gaps in the MMS. MQA research identified 10 hard-to-fill vacancies in the MMS and determined the reasons for the situation including lack of skills, relevant qualifications, experience, high salary expectations and lack of career awareness at the level of the individual; at the level of the organisation, lack of competitive compensation structures to attract potential employees, lack of succession planning and knowledge about career options. Hard-to-fill occupations refer to occupations which employers struggle to find candidates for a sustained period of 6 to 12 months. OHS in the MMS remains a hard to find skill for two main reasons, lack of qualification and lack of experience. The persistence of such vacancy rate can result in more mine accidents and fatalities, making it harder to reach the zero harm targets.

Generally, Skills gaps refers to lack of skills or deficiencies in employees or the absence of specific competencies in employees to undertake a job tasks successfully to required industry standards. We found that, in the context of OHS practice in the MMS, skills gaps refer to the lack of skills or competencies in employees to identity and deal with OHS issues to ensure a safe work environment for all. Skills gaps may arise due to lack of training, new job tasks, technological changes, or new production processes. Some have been shown in the preceding chapters.

Findings revealed that the most common skills gaps according to industry experts for senior managers are related to leadership and managerial skills, whilst technicians and artisans experience skills gaps in people, supervisory and communication skills as well as knowledge and application of new technology. Lower-level employees i.e. plant operators and elementary workers lack computer and numeracy skills. Knowledge and ability to utilise computers and related technology specific to areas of work is imperative for the development of these employees in the sector. We suggested competencies qualification training for supervisors, hazard recognition competencies training module and general OHS training module for the MMS in preceding chapters. Also, there is no registered course dealing with occupational diseases in the MMS. This is despite the fact that occupational diseases continue to impact on the health of workers and also on the productivity of the sector.

CHAPTER 6

ISSUES IN OCCUPATIONAL HEALTH AND SAFETY (OHS) IN MINING AND MINERAL SECTOR (MMS)

6.1 THE ROLE AND SKILLS REQUIRED BY OHS REPRESENTATIVES IN THE MMS

The MHSA (No 29 of 1996 as amended) specifies the role of the OHS in section 30. The main role of the OHS in terms of the MHSA is to:

- Represent employees on all aspects of health and safety.
- Identify potential hazards and risks to health or safety.
- Inspect any relevant document which must be kept in terms of the MHSA.
- Request relevant information and reports from an inspector including requesting an investigation in terms of section 60.
- Participate in consultations on health and safety with the employer or person acting on behalf of the employer and inspector.
- Make representations to the employer or to a health and safety committee on any matter affecting the health or safety of employee.
- Investigate complaints by any employee relating to health and safety at work.
- Examine the causes of accidents and other dangerous occurrences in collaboration with the employer; attend a post- accident inspection.

According to Section 23(b) (MHSA), the OHS representatives can withdraw workers from a dangerous workplace. However, the OHS requires various skills to perform his/her role and to be able to determine and withdraw employees from a dangerous place. The powers and functions of OHS representatives as expressed under the MHSA sections 30 and 23(b) are presented on Table 6.1.

Table 6.1 The powers and functions of OHS representatives (both workplace & full-time) appointed under the MHSA

Section of the MHSA	**Description**
Chapter 3	
Section 30	Role of OHS ● Represent employees on all aspects of health and safety. ● Direct any employee to leave any working place if circumstances arise at the working place. ● Identify potential hazards and risks to health and safety. ● Make representation or recommendation to the employer or to a health and safety committee on any matter affecting the health and safety of employees. ● Inspect any relevant document which must be kept in terms of the MHSA. ● Request relevant information from an inspector. ● With the approval of the employer, be assisted by or consult an adviser or technical expert. ● Attend any meeting of a health and safety committee. ● Request an inspector to conduct an investigation. ● Participate in consultations on health and safety with the employer or an inspector. ● Participate in any health and safety inspection and in any internal health and safety audit. ● Inspect working places with regard to health and safety. ● Investigate complaints by any employee relating to health and safety. ● Examine the causes of accidents in collaboration with the employer. ● Visit the site of an accident. ● Co-operate with the employer in the conducting of investigations and participate in inquiries ● Perform functions agreed by the health and safety committee; or prescribed. NB. The rights and powers apply to health and safety representatives only in respect of the working places for which they are responsible.
Section 23	The employee has the right to leave any working place whenever - (b) the health and safety representative responsible for that working place directs that employee to leave that working place.

Table 6.2 summarises the operational role of OHS representatives on mines in South Africa. According to Coulson (2018), the role can be categorised into three areas of

activity; organisational, technical and human. The three areas of activity were informed by a framework, first used for safety practitioners (Brun & Loiselle, 2002), and then applied to OHS representatives in New Zealand (Harris et al., 2012).

Table 6.2 The activity profile of the workplace OHS representative in South Africa using a framework first developed by Brun and Loiselle

MMS OHS issues	Skills required	Qualifications
Organisational Ensure OHS procedure and policy applied Investigate accidents	Communication skills: • Management skills • Skills in understanding OHS policy and its application on mines • Accident investigation skills • Data collection skills • Writing and reporting skills • Pre-entry checks and documentation • Procedures for underground rail systems to improve safety	MQA/SP/0120/10, Health and Safety Environment (SHE) for OHS representatives composed of three main unit standards: • **SAQA 259622**: Describe the functions of the workplace health and safety representative, 3 credits • **SAQA 244383**: Conduct continuous hazard identification and risk assessment within a workplace, 2 credits • **SAQA 259369:** Explain basic health and safety principles in and around the workplace, 4 credits
Human Train workers in safe work methods. Training on PPE, HIV, TB, non-communicable diseases, emotional wellbeing Discuss OHS issues with workers	• Disease monitoring and control • Psychological skills • Human behaviour skills • Employee OHS capacity needs assessment • Capacity development skills to train employees on PPE and other OHS issues	• Mine Safety Training (COMSOC 1, 2 and 3 by SAIOSH not accredited)
Technical Research ways of resolving OHS issues conduct risk analyses	• Time management • Conflict resolution • Risk management skills • Identify geological anomalies that could pose hazards in mines	• National Certificate: Occupational Safety: Mining and Minerals level 5 (SAQA ID: 79828) (focus on occupational safety)

MMS OHS issues	Skills required	Qualifications
	• Monitoring implementation of Compulsory Codes of Good practices rail bound transport and trackless mobile devices • Skills in monitoring and testing noise hazards • Skills in air quality monitoring • Skills in heat analysis and monitoring • Analysis and monitoring of ergonomic factors such as vibrations, postures • -Analysis and monitoring of Seismicity, rock fall and fall of ground	• National Diploma (SAQA ID: 79829) Occupational Safety: Mining and Minerals is registered at NQF level 5 • SAMTRAC (accredited unit standard based programme) /COMSOC (Unaccredited programme not linked to unit standard) • OFO Code 325705, **Mines Safety Officer** • Occupational Certificate: Safety, Health and Quality Practitioner registered at Level 5 for 256 credits (SAQA ID: 99714) - QCTO registered

(Brun & Loiselle, 2002)

In order for the MMS to comply with the requirements of the MHSA, there is a need for OHS practitioners to possess certain skills as identified in the table above. The following section will focus of the main issues in the OHS in the MMS sector, the skills required, and the qualifications needed to perform those roles in terms of the MHSA. This will assist in identifying the gaps in the sector and in specifying the possible training programmes required to meet these gaps.

6.2 OHS ORGANISATIONAL-RELATED SKILLS ANALYSIS

The previous chapter presented the OHS skills required in terms of the MHSA. These skills were broadly identified under three main sub-categories: Organisational, technical and human or employee related. This and the following two chapters present the details of these required skills within the different MMS sub-sectors. Additionally, stakeholder experiences, views on needs for these skills and OHS issues within the sub-sectors;' supply of these skills in the industry and possible gaps, are addressed. The chapter also provides insights into the alignment of the OHS skills required by the industry, with the QCTO qualification framework.

6.2.1 Significance of organisational OHS issues and critical skills required

The South African MMS sector continues to have OHS challenges resulting from lack of proper representation by OHS practitioners on health and safety issues. Given that there is no legislative requirements for minimum academic qualifications in terms of section 30 of the MHSA for OHS representatives, many of practitioners lack skills in record keeping, administration, organisational management, and policy awareness. Most notably, the review of OHS organisational issues during various stages of the mining activities in the analysed sub-sectors revealed that there is a need for representatives to have adequate OHS organisational skills at all the different stages of the mining life cycle. This would ensure that OHS policies, processes, systems and procedures are in place and followed throughout the life cycle of the mine as indicated below.

Table 6.3 Significance of OHS organisational skills issues at different stages of the life cycle

MMS sub-sector	Design/planning	Construction	Operation	Closure	Rehab
Gold mining					
PGM mining					
Other mining					
CLAS					
Diamond mining					
Diamond processing					
Jewellery manufacturing					N/a
STM					

LEGEND	Negative – negligible	Negative – low	Negative – moderate	Negative – high	Positive

According to Table 6.3 above and in terms of the MHSA, it is the role of the OHS representative to ensure that OHS organisational issues are covered in company OHS polices, processes, systems and COPs. Findings in this study showed that such a role is very significant at various stages of the development of the mining cycle across the MMS except in services incidental to the sector as many of these services are not classified in mining terms and do not require to be included in OHS policies, procedures, and systems.

Chapter 2 of the MHSA mandates all companies in the MMS to have measures to: (i) maintain safe environments; (ii) establish polices and processes for health and safety, and to (iii) develop procedures, training etc. All OHS representatives need skills to be able to monitor these processes, procedures, training, and the OHS system of the organisation. They require skills to engage the DMR for investigation, record-keeping and to ensure that operating procedures are in place.

Table 6.4 Critical skills – OHS organisational skills

Critical skills – OHS organisational skills
• Communication skills
• Management skills
• Leadership skills
• OHS policy, systems and processes
• Stakeholder engagement including DMRE for investigations
• Writing and reporting
• Document review
• Checks on processes for TMMS and underground railbound equipment

Given the legislative mandate of the OHS on the mine and its role in ensuring that OHS skills are in place, stakeholders were able to identify critical skills required by the OHS to perform this role including: communication skills to be able to engage all relevant stakeholders on OHS policy issues and organisational issues.

6.3 OHS ORGANISATIONAL SKILLS SHORTAGES IN THE MMS

While most of the skills identified as critical to the OHS organisational role exist in SA, the study revealed that some of these skills are still not incorporated into current OHS skills programmes and qualifications within the SA market. The industry identifies a shortage in OHS skills, and this observation was supported by the stakeholder investigation and the 2018, MQA sector skills plan. A further complication as it relates to OHS skills is the fact that there is no OHS-approved level three and four NQF qualification that can give

OHS practitioners the adequate skills required to operate at the level required by the MHSA to ensure adequate health and safety systems, policies and procedures. There is an urgent need to "upskill" by introducing level three and level four qualifications that can empower OHS representatives and safety personnel as required by the Act.

Table 6.5 Demand versus supply perspective – OHS organisational-related skills shortages

OHS organisational skills required	Skills identified as in short supply
• Communication skills	• OHS policy, systems and processes
• OHS Leadership and Management	• Leadership skills • Management skills
• Stakeholder engagement including DMR for investigations	• Writing and reporting • Incident investigation
• Checks on processes for TMMS and underground railbound equipment	• Document review • Process evaluation

6.4 ALIGNMENT OF ORGANISATIONAL OHS SKILLS REQUIREMENTS AND QUALIFICATIONS

6.4.1 OHS organisational skills and required qualifications and experience

The shortages of the abovementioned OHS organisational skills are largely linked to various factors including the fact that there are no specific entry qualification requirements for OHS representatives. Additionally, technology is changing within organisations, policies around MHSA and other regulatory policies require expert knowledge for effective implementation at the mines. Many of the required OHS organisational skills can be acquired by studying some of the existing MQA and OHS qualifications and programmes as summarised in Table 6.6 below:

Table 6.6 OHS organisational skills and required qualifications

Skills	Qualifications	Experience
OHS policy, systems and processes analysis and implementation	• **SAQA 259622**: Describe the functions of the workplace health and safety representative, 3 credits	One to three years
• Writing and reporting	N/A	One to three years
• Document review	N/A	One to three years
• Communication skills	• **SAQA 259369:** Explain basic health and safety principles in and around the workplace, 4 credits	One to three years
• Stakeholder engagement including DMRE for investigations	• **SAQA 259369:** Explain basic health and safety principles in and around the workplace, 4 credits	One to three years
• Leadership and management on OHS	None	None
• Incident investigation skills	• **SAQA 244383**: Conduct continuous hazard identification and risk assessment within a workplace, 2 credits	One to three years
• TMM process evaluation	• **SAQA 244383**: Conduct continuous hazard identification and risk assessment within a workplace, 2 credits	One to three years
• Checks on processes for TMMS and underground railbound equipment	• **SAQA 244383**: Conduct continuous hazard identification and risk assessment within a workplace, 2 credits	One to three years

6.4.2 OHS organisational skills and identified shortages

The following diagram illustrates the organisational OHS related skills that are demanded by the MMS sub-sectors and alignment thereof with registered QCTO qualifications or those that are currently under profiling with the Quality Council. It highlights the fact that there is a currently need to expand OHS skills beyond level one and two, as part of the greater plan of filling the gaps that exist in level three and four OHS organisational skills. It further shows that there is need to develop soft OHS skills including communication, and report writing to enhance the OHS roles within the MMS.

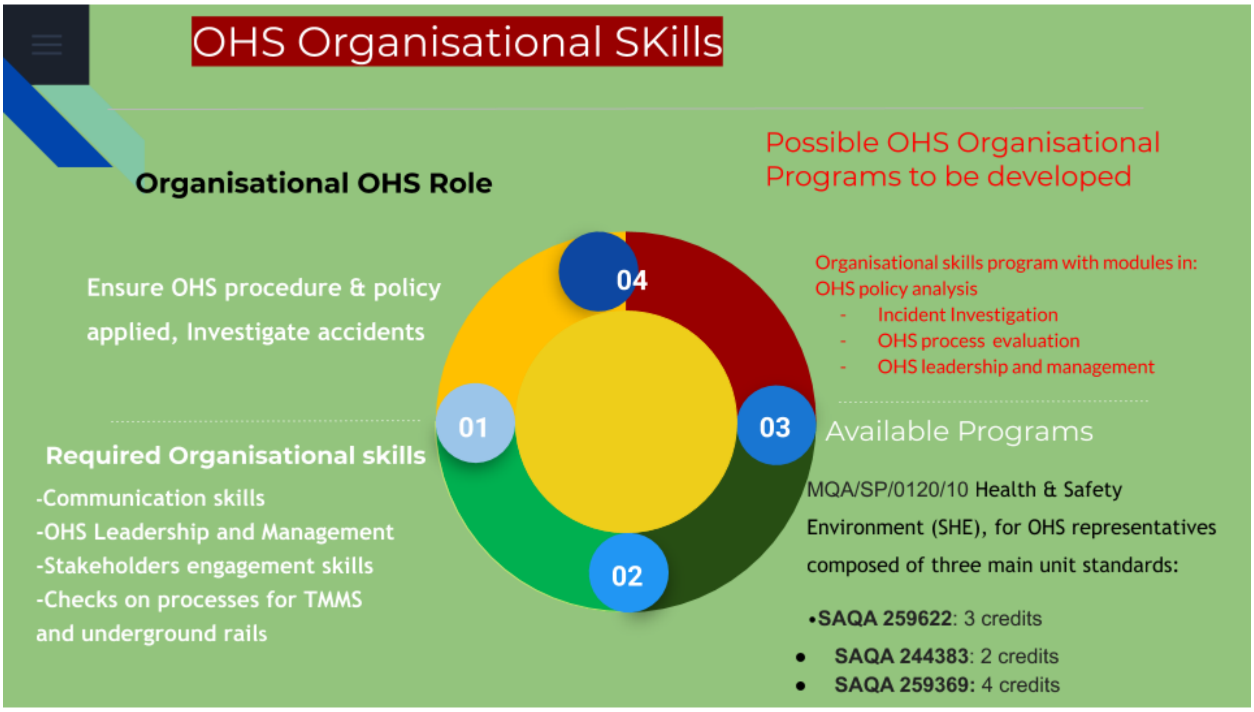


Figure 6.1 OHS organisational skills required, available programmes and possible required programmes

The review of stakeholder engagement showed that many organisations develop their own OHS skills development programmes to complement their SAQA accredited and non-accredited OHS programmes. However, there is a need develop content for organisational OHS skills that can be aligned to SAQA and QCTO to improve OHS Skills in the industry.

6.4.3 Capability and capacity of local institutions to supply of OHS skills

As mentioned previously, the majority of OHS skills required in SA do not require a person to have graduated from the university but instead, individuals can possess post matric FET courses and diplomas can suffice for a majority of the skills. However, for purposes of career advancement, there would be a need for further higher education qualifications in OHS. Table 6.7 below presents a high-level summary of the supply of OHS skills based on data from the MQA and other institutions of higher learning.

Table 6.7 Supply of OHS related skills: Qualifications registered with SAQA related to OHS in the MMS

NQF sub-framework	Qualification ID	Qualification title	NQF level
HEQSF	16098	Diploma: Mine Health and Safety	Level N/A: Pre-2009 was L5
HEQSF	16094	Certificate: Mine Health and Safety	Level N/A: Pre-2009 was L5
OQSF	99714	Occupational Certificate: Safety, Health and Quality Practitioner (Occupational Health and Safety Practitioner)	NQF Level 05

(SAQA, 2019)

All of the qualifications highlighted in Table 6.7 above are offered mainly by MQA accredited service providers and other institutions of higher learning especially institutions, for example, the university of Venda currently offers a diploma in Mine Health and Safety.

Table 6.7 shows that there is need for other level three and level four qualifications aimed at training OHS representatives on organisational OHS skills especially related to incident investigation, MHSA and other policy implementation analysis.

6.5 CAREER PATH DEVELOPMENT OPPORTUNITIES

As indicated above, to be able to work in the field of OHS, The MHSA makes no formal qualifications requirements except that one must have been a miner and thus OHS representatives take up the role with different levels of qualifications. This lack of consistency makes difficult to expect all OHS representatives to perform at the same level.

There is a need to take the field of OHS to the next level. There is a need for a clear career development path for OHS practitioners within MMS. The fact that OHS representatives have a three-year placement and go back to their role makes it hard for sustained career development. The possible opportunities for career development for OHS representatives are presented below.

Table 6.8 Career path opportunities for organisational related skills and occupations

OHS skills	Professional fields	Possible career path
• OHS policy implementation analysis • Writing and documentation review • Communication • Stakeholders engagement • TMM incident investigation • OHS leadership • OHS management	• OHS representatives • OHS officer • UNION shop stewards	• OHS officer • OHS health officer • OHS manager • OHS risk officer • OHS risk analyst • Risk management • Safety officer • OMP assistant

The following can be noted from the above:

Given the regulatory, economic and social imperative of OHS, there is a need to give priority to the development of OHS career paths in the MMS as a way of ensuring long term career progression that is attractive to the right candidates.

6.6 HUMAN FACTOR OHS RELATED SKILLS

Similar to the previous chapter, this section of the report provides insight into the OHS skills' demand and supply shortages but specifically focuses on human-factor related OHS skills. The chapter also includes the alignment of OHS skills with the QCTO qualification. It must be noted that evidence from the fieldwork within the study pointed to the fact that human factors remain the leading cause of OHS issues in the MMI.

6.6.1 Significance of Human factor related issues and critical skills required

Our literature review showed that OHS issues are mostly caused by human and psychosocial factors (Buckle & Devereux, 2002). Human behaviour and habits (smoking and drinking) are significantly associated with injury and other diseases. Workers who were regularly consuming alcohol had comparatively higher chance of experiencing injuries compared to other workers (Kunar et al., 2008). Psychosocial factors include workload, job control, and social support system (Dozolme, 2017). Work environment combined with personality traits and an individual's psychological condition may lead to inappropriate actions that may eventually predispose them to injury at work (Lu & Chen, 2015:60). Friedman et al., 2018; Abbasi, 2018) revealed that job burnout and job dissatisfaction along with emotional instability were associated with higher rates of injury. Similarly, Phiri (2015) identified dissatisfaction with support from colleagues or supervisors as the strongest work-related psychosocial risk factor. It is important for OHS representatives and other OHS experts to have adequate skills and capability to analyse, monitor and deal with the impact of human factor related OHS issues. The respondents and stakeholders in this study agreed that most OHS issues were a result of the involvement of human factors rather than technical and/or organisational factors. Some of the critical skills identified by stakeholders, as being needed to deal with human related OHS factors, included disease monitoring and control, psychological skills, human behaviour skills, skills to train employees on OHS issues and skills to train employees on the use of PPE equipment.

Table 6.9 Critical human factor related skills identified by industry

Critical human factor related skills identified by industry
• Disease monitoring and control • Psychological skills • Human behavioural skills • Skills to train employees on OHS issues • Skills to train employees on the use of PPE • Communications kills • People management skills equipment

Table 6.10 Significance of human factor OHS related issues at different stages of the life cycle

MMS sub-sector	Design/planning	Construction	Operation	Closure	Rehab
Gold mining					
PGM mining					
Other mining					
CLAS					
Diamond mining					
Diamond processing					
Jewellery manufacturing					
STM					

LEGEND	Negative – negligible	Negative – low	Negative – moderate	Negative – high	Positive

The issues that MMS sub-sectors deal with when it comes to human factor related OHS matters are, in many instances, similar across the entire MMS; however, some are sector specific. Furthermore, the negative effects of human factor related OHS issues as indicated by the stakeholders, appears to be more detrimental to the MMS than organisational OHS issues:

Human factors were identified as being more dangerous in underground mining than in surface mining. Stakeholders indicated that lapses in pre-entry assessments sometimes put employees at OHS risk due to behaviour before entering the mine such as drinking, smoking, negligence in the use of PPE among others.

Critical skills – Human-related OHS

- Disease monitoring and control
- Psychological skills
- Human behaviour skills
- Skills to train employees on OHS issues
- Skills to train employees on the use of PPE equipment
- Communications skills

Figure 6.2 Critical skills – human-related OHS

Table 6.11 Critical requirement of OHS human factor-related skills at different stages of life cycle of mines

Skill	**Design/planning**	**Construction**	**Operation**	**Closure**	**Rehab**
Employees diseases monitoring					
Psychological skills					
Human behaviour skills sampling					
Sills to train employees in OHS issues					
Skills to train in PPE equipment use					

Explanation of the colour-coding: the number of sub-sectors that indicated a particular skill to be highly critical	None	1 sub-sector	2 sub-sectors	3-4 sub-sectors	5 sub-sectors

6.7 SHORTAGES AND GAPS- HUMAN FACTOR OHS SKILLS

According to the findings from the stakeholder engagements in the MMS, there was a shortage of behaviour related OHS-skills in the sector especially given the fact that current OHS skills programmes offer limited behavioural skills to OHS representatives.

Given the significance of human factor related OHS skills in the MMS, the industry will continue to have a need for skills that can assist industry towards the achievement of its zero-harm target.

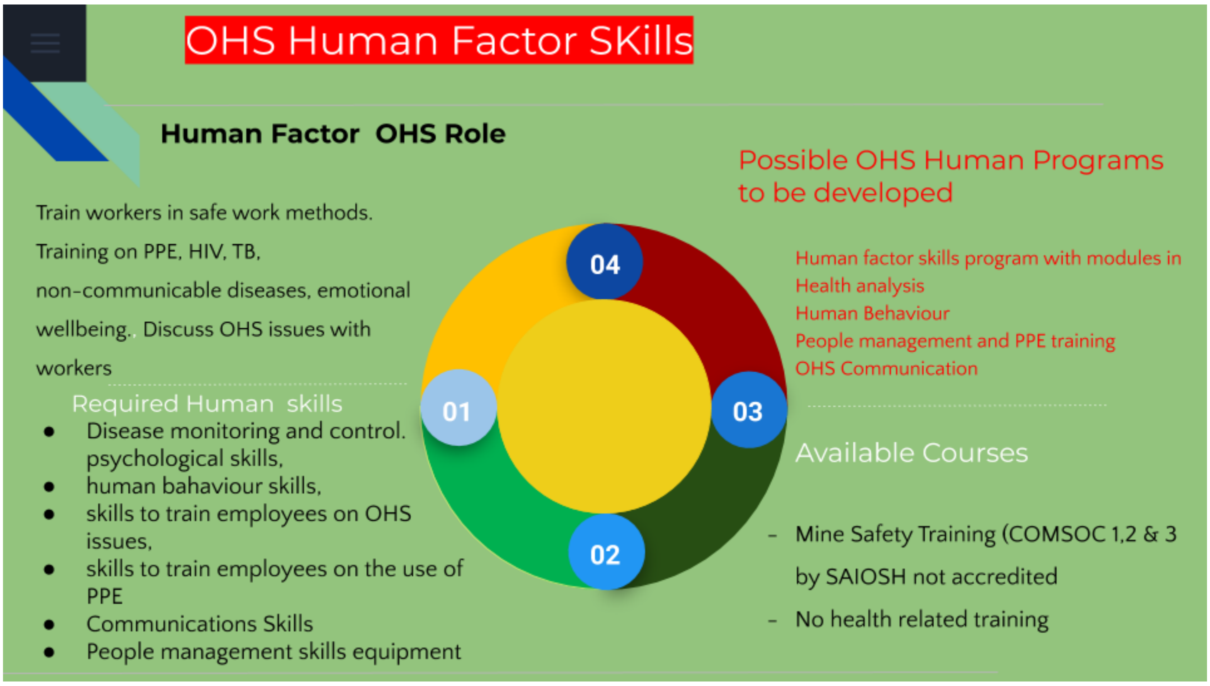


Figure 6.3 Human factor-related OHS skills, available courses and programmes and possible programmes to be developed

Figure 6.3 above, presents the required skills to perform the human factor related aspects of OHS role. Additionally, the figure highlights currently and future courses and programmes that exist or can be developed to deal with human factor related OHS issues.

6.8 TECHNICAL OHS-RELATED SKILLS

6.8.1 Significance of technical OHS issues and critical skills required

Mining in the MMI involves different types of OHS risks that required technical OHS expertise to be able to identify and deal with. The literature review conducted in this study pointed to the fact that the physical ergonomic aspects of the work environment are critical risk factors in mining (Ncube, et al, 2016). It was also established that repetitive motions, forceful exertions, vibration exposures, poor/awkward posture, forceful gripping and jolting/jarring, all cause occupational injuries and accidents in the MMS (Dlambulo & Motsie, 2014; Nzingana, 2013; Mabika, 2018). Further literature showed that a variety of common injuries could originate following irregular motions, prolonged awkward postures of the workers body and biomechanical overload amongst miners (Kim, 2018).

TECHNICAL OHS SKILLS

- Time management
- Methane detection/heat analysis
- Risk management skills
- Identify geological anomalies that could pose hazards in mines
- Monitoring implementation of compulsory codes of good practices rail bound transport and trackless mobile device
- Skills in monitoring and testing noise hazard
- Skills in air quality monitoring
- Skills in heat analysis and monitoring
- Analysis and monitoring of ergonomic factors such as vibrations, postures
- Analysis and monitoring of seismicity, rock fall and fall of ground

Figure 6.4 Critical technical skills required by industry

Ergonomic risk factors have been associated with the increased prevalence of occupational injuries and illnesses (Friedman et al., 2018). Some of these factors include time aspects of work. Predictable risk factors may include percentage of time with hands above the shoulders, working with hands above the shoulders, and working with trunk or neck flexion (Kim, 2017). There is need for OHS practitioners to analyse and understand the risk factors at all stages of their operations within the mines. It was evident from the field that the technical OHS skills required differ from one level of the mining cycle to the next and also that different sub-sectors had different prevailing mining environments and risks. The significance of technical OHS issues in the MMI as identified by stakeholders is presented below.

Table 6.12 Significance of OHS technical issues at different stages of the life cycle

MMS sub-sector	Design/planning	Construction	Operation	Closure	Rehab
Gold mining					
PGM mining					
Other mining					
CLAS					
Diamond mining					
Diamond processing					
Jewellery manufacturing					N/a
STM					

LEGEND	Negative – negligible	Negative – low	Negative – moderate	Negative – high	Positive

The nature and type of OHS technical issues that the MMS sub-sectors deal with during various stages of mining activities vary from sub-sector to sub-sector and sometimes from mine to mine. In general, though, the following are the most common OHS technical challenges that the businesses operating in the MMS are faced with:

- **Gold mining**: Gold mining is prone to various technical OHS issues due to the different processes involved from blasting, crushing, transporting grinding, leaching, elution, water treatment and tailing/disposal. Humans (miners are involved together with machines in the various processes and this exposes miners to such OHS issues including dust, noise, seismicity/FOG and FOR, technical knowledge in operation of machines among other OHS issues. OHS issues are most relevant during the operational phase and relate to noise due to blasting of rocks, dust, heat, FOG, issues with TMM and other machinery that impacts on the health and safety of employees on the mine. There is need for the OHS representative to be aware of the nature and extent of these issues and how they can be dealt with to reduce the negative impact on employees. In order for the OHS representatives to be able to adequately contribute to these issues they need to have adequate skills and experience in OHS.

- **PGM mining:** The PGM mining process also involves blasting, crushing, transporting and refining. The different processes are prone to different OHS issues similar to those of the gold mining process. The different stages in the PGM expose miners to OHS issues including dust, noise, and seismicity/FOG and FOR, TMM risks, among other technical risk. In terms of the MHSA, the mines have the obligation to ensure that all miners are well and safe during the PGM process. However, in practice, the OHS officers and representatives need to have the technical knowledge and skills in OHS to ensure the OHS issues are adequately identified and dealt with to ensure safety for all workers.
- **Other mining:** There exist different OHS issues in other mining sectors as they also involve blasting, grinding, TMMS etc. These OHS issues, if not adequately managed, will impact negatively on the health and safety of employees. The impact of technical OHS issues, in sectors such as the gold and platinum mining sectors, are most prevalent during the operational phases of the mining activity.
- **CLAS:** During cement, lime, aggregate and sand mining, various OHS technical issues can be identified due to the mining process. The process in certain instances involves blasting of quarries, use of large equipment, and other machinery that pose different health and safety risks to employees. There is a need for OH officers and representatives on the sites of the different operations to understand how to analyse OHS issues and to ensure timely interventions including asking workers to leave dangerous work environment in terms of the MHSA. In order for an OHS representative to effectively play this role, various technical skills are required.
- **Diamond mining:** Diamond like many other minerals can be mined both underground and open pit. Diamond mining also involves various technical OHS issues in different stages of the mining process. Though diamond mining uses less hazardous chemicals compared to gold, the technical OHS issues still persist especially during the operations phase which has risks such as blasting, transportation, and purification processes of the metal. OHS representatives need

skills and knowledge to ensure that all OHS issues involved in the processes are identified and dealt with to minimise the risk to employees.

- **Jewellery manufacturing:** This process in many cases involved the use of chemicals and machinery and also involved a range of OHS issues. However, the OHS issues in this MMI subsector are less than those of actual mining processes. Even so, there need for OHS representatives to fully understand the risks involved in using certain chemicals on the manufacturing process.

Given the fact that the OHS issues are particularly significant in underground mines especially in gold and coal mines compared to other mines, it is no surprise that these sub-sectors require related critical skills. Even though surface mining does not face the same level of OHS issues as underground mining, the feedback received from stakeholder consultations indicates that there is need for OHS skills and competencies both in underground and surface mining to ensure the safety of all miners, both underground and surface. Overall, all stakeholders agreed that the current state of OHS skills needed upward revision. In fact, the stakeholders, particularly lamented the lack of behaviour-based OHS modules and also the lack of implementation of the currently approved level 5 OHS programme.

Table 9.2 below provides a summary critically required OHS technical skills across MMS sub-sectors. It also highlights the OHS technical skills that are deemed critical by more than three sub-sectors (colour-coded cells in dark orange), making them particularly high in demand in South Africa.

Table 6.13 Critical requirement of technical OHS-related skills at different stages of life cycle of mines

Skill	Design/planning	Construction	Operation	Closure	Rehab
Time management and conflict resolution					
Risk management					
Identifying geological anomalies					
Monitoring the implementation of compulsory codes of good practices for TMMS					
Air quality monitoring					
Noise monitoring					
Heat monitoring					
Vibration analysis					
Posture analysis skills					
GOG monitoring and analysis					
Knowledge of the MHSA					
FOR analysis					

Explanation of the colour-coding: the number of sub-sectors that indicated a particular skill to be highly critical	None	1 sub-sector	2 sub-sectors	3-4 sub-sectors	5 sub-sectors

The study revealed that technical OHS issues are significant throughout the mining sector. It was also revealed that technical OHS issues are most significant during the operations phase of the mining process. Issues resulting from rock falls, fall of ground and TMMS are most significant during the operations phase and mostly in underground mining than in surface mining. It is therefore critical for the MMS to design the right technically oriented skilled programmes to deal with issues of Technical OHS Skills in the MMS.

The following section summarises the technical skills required, skills gaps and possible programmes to be developed to deal with the technical skills gaps in the MMS.

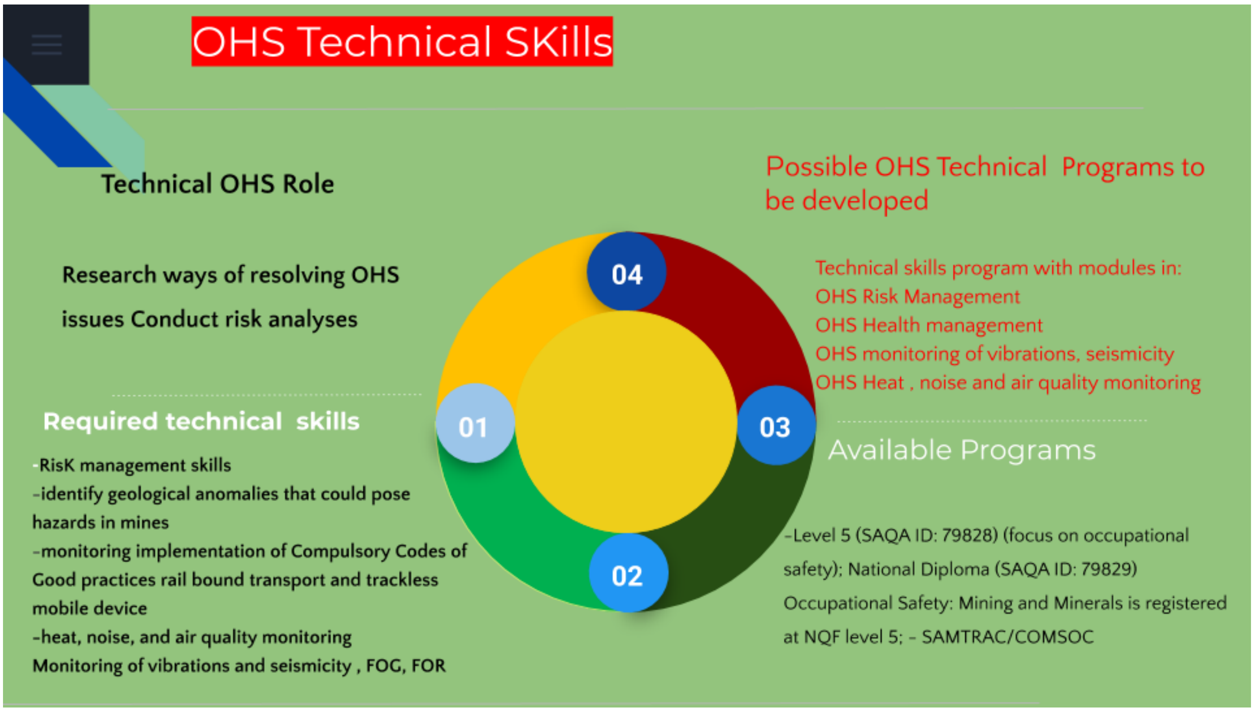


Figure 6.5 OHS technical skills

The literature reviewed and evidence from stakeholder consultations showed that the lack of technical skills is the fundamental cause of mine accidents and fatalities. OHS require technical skills in risk management, monitoring of FOG, FOR, seismicity and other technical competencies like noise monitoring, air quality, and heat monitoring. Note is made of the fact that a lack in a specified requirement for technical OHS skills within the MHSA, means that the industry must specifically train OHS representatives in a range of additional skills including: risk management, monitoring of vibrations, air quality, heat quality monitoring and other technical skills as presented in Figure 6.5.

6.9 DRIVERS OF OHS SKILLS DEMAND AND SUPPLY

6.9.1 Demand and supply drivers of OHS skills today

The demand and supply of OHS skills in the MMS is driven by various factors, some of which imply more pressure than others. The following table summarises the most prominent drivers of supply and demand of OHS skills in the MMS in no particular order.

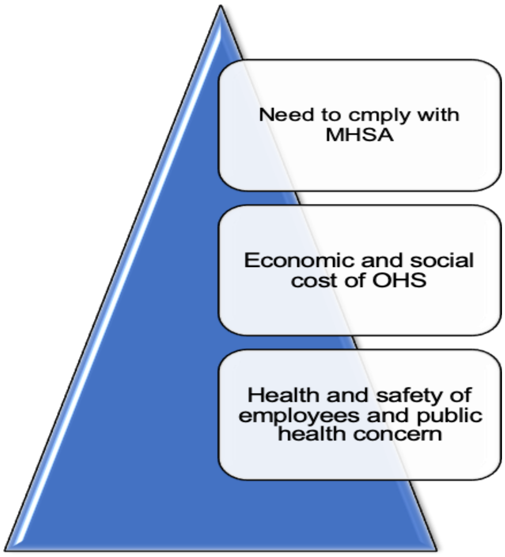
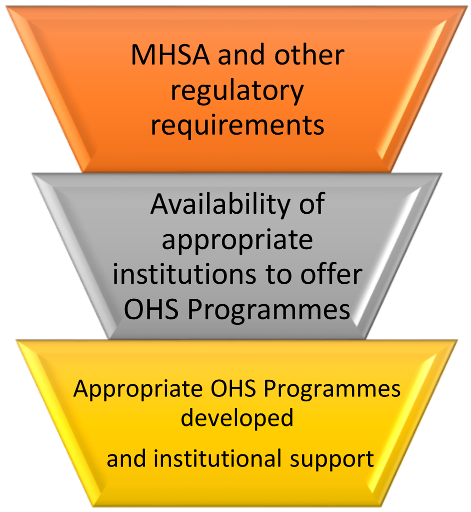
<table>
<tr><th>Demand of OHS skills</th><th></th><th>Supply of OHS skills</th></tr>
<tr><td rowspan="3">
</td><td>Technical OHS skills</td><td rowspan="3">
</td></tr>
<tr><td>Human/ behaviour OHS skills</td></tr>
<tr><td>Organi-sational OHS skills</td></tr>
</table>

Figure 6.6 Demand and supply drivers of OHS skills in the MMS

The **demand** for OHS skills in the MMS is largely driven by the need to continue producing value for shareholders and to comply with the MHSA. The research found that in certain instances, the demand was purely due to compliance needs with the MHSA and lacked emphasis on OHS leadership and/or culture within the organisation. Many of the organisations interviewed indicated that the most critical implication of not having access to the required OHS skills was the risk of lack of compliance with the MHSA. The MHSA compels mines to comply with safety and health requirements and to ensure that all miners return home unharmed daily.

This study established in the literature review that occupational injuries and ill-health have significant social and economic implications for individuals, their families and their communities. It was also established that OHS issues 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% of GDP in various countries**.** 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 caregiving by families and the community. Poor communities tend to bear the brunt of externalised 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.

We further established from literature, that occupational accidents and health hazards can also affect public health and safety, and the environment. Given the scope and costs of OHS to the MMI and SA economy, there is a need to continue to assess and identify ways to deal with OHS issues and to ensure that the right skills are available.

With respect to supply and demand factors related to OHS skills, the MHSA and the need for organisations to comply are fundamental drivers of the supply of OHS skills. Experience is another critical driver of supply, and there is a call for individuals to widen their OHS skills in order to allow for career development and better OHS performance of the MMI. There is a need for institutions to offer skills development programmes that cover all aspects of OHS including technical, organisational and behaviour/human skills. Such skills development depends on the availability of internships, apprenticeships, mining orientation and learnerships, formal OHS qualifications and workplace training. There is a need to align the qualifications being offered with SAQA and QTCO going forward. Basic education and quality of TVET OHS programmes also influence the supply of OHS skills. The supply of OHS skills is also influenced by the availability of accredited service providers who can assist in the implementation and quality control of these skills programmes.

6.9.2 Outlook for OHS skills in mining

Technology and regulations are changing the way mining is done in South Africa and the world over. However, the core business and mining processes remain largely unchanged and still pose health and safety risks to employees daily. The mines of the future will require a high level of a combination of technology, human and organisational skills to deal with OHS issues and progress towards zero harm. According to (Kirkby, 2002), there is immense pressure on the MMI to find new ways of improving production efficiency and optimising safety obligations. Given that the tripartite stakeholders in the sector in line with the MHSA have agreed to work towards zero harm by and various targets set for 2024, there is a need to ensure that the right OHS skills are developed, and used in the sector to support the realisation of these ideals and goals.

In the context of the above, all the mining sub-sectors are likely to experience an increased demand for various OHS related skills, considering that OHS skills are part of the critical investor and regulatory requirements and that there will always be a need for OHS skills to fulfil legislative requirements regarding safe and healthy mining. For example, S22 of the MHSA and various other sections requires the mining companies to ensure that the OHS representatives appointed are adequately skilled to perform their role. The MHSA further states that the overall responsibility of health and safety is for the mining company, this therefore places a demand on mining companies of the future to prioritise health and safety and to seek skills and competences that can enable them to operate safely.

Given the economic, reputational and social cost of OHS issues, mines of the future who also want to be good corporate citizens will also seek the relevant OHS skills and competences to ensure that they minimise their spending on compensation and also reduce reputational damage and any other impact of OHS issues on the organisation and society. Calls to strengthen OHS regulations can also place further demand on the mining sector to seek to operate in a safe way. Technology is changing the mining industry and OHS issues of the future are also changing. There is an urgent need for the industry to start looking for innovative technology enabled OHS solutions to improve health and safety in the sector.

While driverless trucks have improved the process of mining, there remain OHS issues with such technology and it is therefore imperative to invest in technology enabled OHS skills development to improve the mines of the future. Different MMI sub-sectors will require certain OHS skills more than others depending on the development and application of mining technology in the sector.

Table 6.14 Description of selected emerging practises in the future of OHS in mining

Characteristic	Conventional practice	Emerging practices to adopt
Safety	• Workers' safety is solely a function of training, procedures, policy and change • Access, privileges, status and management employees is delegated to line managers and informal processes	• New smart programmes and technologies, such as location awareness technologies, GPS, RFIDs and collision detection/avoidance
Health	• Worker health a function of OMP performance • Personal factors affecting health	• Technology enabled health monitoring systems • Technology enabled human behaviour monitoring systems • Technology enabled health services using 4IR
OHS training	• Sills based mostly theoretical and workplace training	• Predictive OHS training, virtual and face-to-face, enabled by big data and 4IR

Considering the above, some sub-sectors may experience a decrease in the demand for OHS skills that are currently in need and that have been identified to be in short supply or readily available; this has also been confirmed during interviews with stakeholders. The need for one type of skill will, however, be replaced by the need for another type, and re-skilling as well as the restructuring of the labour force in the MMS will be required. There is a need to re-look at OHS skills development in the context of available skills, required skills and the use of technology to improve OHS practices.

CHAPTER 7

CONCLUDING REMARKS AND RECOMMENDATIONS

7.1 CONCLUDING REMARKS

Since the transition to democracy in 1994 in SA and the implementation of the MHSA, in 1996, South Africa has moved towards a risk-based approach to OHS. The tripartite industry has set targets for achieving zero harm by 2024. Various initiatives are in place to ensure that. The MQA was established to ensure that the relevant skills are developed to deal with OHS issues in the sector.

In terms of the MHSA, there is a need for three core skills to deal with OHS issues: organisational skills, human behaviour skills and technical skills. Depending on the contextual needs these skills could be rolled as skills programmes, part qualification and full qualification with critical need to reduce injuries, fatalities and health related diseases in workplaces within the sector. Mining in SA is changing with the adoption of new mining technology. Given the differences in OHS risks across mining commodities and also differences between OHS risks in surface and underground mining there is a need for the development of different OHS programmes to deal with these differences.

This study reviewed various South African policies, legislative frameworks, and conventions related to OHS and found out that there is a need for a wide-ranging OHS skill set related to organisational OHS role, human related OHS role and technical OHS role required by the mining industry to possess and have access to for it to be able to deal with OHS issues and also comply with these legislations and guidelines and to ensure that the industry moves closer to the zero harm goal.

A total of 18 companies within the MMS were engaged through two stakeholder engagement focused group discussions, telephone interviews, and semi-structured questionnaires to gain an insight into the current OHS issues in the MMS, the skills required to deal with OHS issues and the demand and supply of the relevant OHS skills within the above-mentioned fields.

The gathered data revealed that most OHS skills arise from knowledge gained from working in the mines for many years, OHS training, in house training programmes and other accredited L1 and L2 OHS programmes offered by other service providers including educational institutions such as TVET colleges. In addition to this, some skills are rather mine - and/or sector-specific; and can only be experienced by working in that sector. It was identified that, despite the number of accredited and unaccredited programmes in OHS in the SA market, there is a huge gap in developmental initiatives that address human related OHS programmes, technical OHS programmes, and organisational OHS programmes in terms of the requirements of the MHSA.

The following diagrammatic representations below, summarise essential and scarce OHS skills within the MMS. These skills were compiled based on a review of OHS role in terms of the MHSA, and a review of the current OHS programmes in the SA market. There is a need for the MQA to consider both long term and short courses of OHS skilled programmes in the areas above in order to enable industry to have the required organisational, human related and technical OHS skills both to deal with OHS issues and to comply with the MHSA.

Table 7.1 Critical OHS skills shortage in the MMS

Organisational OHS skills	**Human Related OHS skills**	**Technical OHS skills**
Organisational skills programme with modules in: • OHS policy analysis • Incident Investigation • OHS process evaluation • OHS leadership and management	• Health analysis • Human behaviour • People management and PPE training • OHS communication	• OHS risk management • OHS health management • OHS monitoring of vibrations, seismicity • OHS heat, noise and air quality monitoring

Currently, companies address skills gaps through the following interventions:

- Outsourcing independent consultants
- Offering bursaries
- Providing in-house accredited training to staff and informal training programmes

- Taking staff on external courses such as SAMTRAC, National Certificate: Occupational Health and Safety: Minerals and Mining certificate, Skills Programme: Occupational Health and Safety activities for: Part Time/Workplace Representatives and Shop Stewards in the Mining and Minerals – (MQA/SP/0120/10)

However, this study found out that some of these programmes have both low intake and low impact on the industry in relation to improvement in the OHS outcomes. The SAQA74269 Occupational Health and Safety programme has a scope outside of the MHSA and thus needs to be revised or replaced with more appropriate programmes.

The industry would welcome new relevant skills programmes that would enable them to comply with the MHSA. Therefore, the MQA and all relevant stakeholders need to consider the development of new relevant skills programmes in terms of the MHSA to fill the skills gaps and deal with OHS issues in the sector. This study also found that OHS is not fully developed in the MMS. This makes it difficult for career advancement. OHS are appointed with or without qualifications and they serve for the three-year period and return to their role with no OHS-related career advancement path.

The study also found out that the fact that the MHSA specifies no minimum education or qualification requirements poses a limitation for career development of the OHS. There might be a need to review certain sections of the MHSA to strengthen these OHS requirements.

The study confirmed that there is a low uptake of for some of the MQA developed programmes including the L5 OHS programme (National Diploma in Occupational Safety). This was due in most part to the misalignment of some of these courses to the requirements of the MHSA. There is a need for the MQA to review such programmes and either redesign or replace them with more appropriate programmes.

It was also concluded that current internships, apprenticeships, OHS learnerships and skills programmes offered in SA have limited human factor and health programmes among others. Institutions offering skills OHS programmes lack various organisational human factor related and technical OHS skills modules required to deal with OHS issues and to ensure that companies are compliant with the MHSA and work towards the “zero harm” goal.

Finally, technology advances continue to change the way mining is done in South Africa and due to changes in technology, different MMS subsectors are experiencing and increase in technology enabling OHS skills to meet the legislative, investor related and social requirements of OHS in the MMS. Mines of the future will want to be good corporate citizens and will also seek the relevant OHS skills and competences to ensure that they minimise their spending on compensation and also reduce reputational damage and any other impact of OHS issues on the organisation and society. While driverless trucks have improved the process of mining, there remains OHS issues with such technology and it is therefore imperative to invest in technology enabled OHS skills development to improve the mines of the future.

7.2 RECOMMENDATIONS

Although the above section deals with the current shortages of OHS skills in the MMS, the situation is likely to exacerbate in the future, if steps are not taken to deal with the current OHS issues and skills required. In this context, the following recommendations are proposed to be considered by the MQA to address the identified gaps, shortages, and weaknesses in the OHS skills programmes:

- **Revise existing OHS qualifications such as SAQA 74269 Occupational** Health and Safety **to better align with the requirements of the MHSA and the needs of the MMS in relation to green skills.** The study revealed that there is a lack of alignment between the existing OHS programmes and the MHSA. There is a need to align these programmes to the MHSA to ensure that they focus on the organisational, human related and technical skills required to deal with OHS issues in the MMS.
- **Audit current skills providers and ensure that the programmes offered are aligned to the needs of the MMS.** Stakeholders indicated that some of the skills programmes are not aligned to the changes in the MMS due to technology and there was also an issue of dealing with the delivery methodology including the language of instruction.

- **Work with other SETAs to incorporate certain existing programmes into the MMS.** It was realised that there are existing programmes in other SETAs that can be incorporated into the MMS to deal with OHS issues and to align with the MHSA. It was revealed that such courses as communication of OHS issues, OHS leadership and OHS organisational culture required to deal with OHS organisational issues can be adopted from other SETAs.
- **Align existing programmes with QCTO.** It was revealed that there exist certain OHS skills programmes including in-house programmes and other non-accredited programmes offered by certain service providers that can be developed further and aligned to qualifications. The MQA needs to work with other stakeholders and service providers in the sector to review and align existing programmes to QCTO
- **Examining in-house programmes offered by various companies in the MMS and see how to develop some best practice OHS programmes from there**. Certain companies indicated that they have developed certain in-house programmes that deal with OHS issues and such programmes have worked in these companies especially in the December- to January "silly season". The MQA should consider working with the MHSA and other stakeholders to identify some of these best practices and see how to incorporate them into OHS formal programmes for the MMS industry or certain sub-sectors where appropriate
- **Develop OHS career path in the MMS for people to specialise in health and safety in areas such as engineering, metallurgy and mining (move from Safety reps, Safety officer, and Chief safety officer to Chief safety manager.** Also develop a generic programme or course offering for the current cohort of safety reps focussing on technical elements of health and safety focussing of developing competence for the assessment of dangerous working conditions due to factors methane gas, FOG, seismicity, assessment of heat and so forth for specific purpose of reducing the current fatalities, injuries and diseases in the MMS. This study revealed that there are gaps in the process of appointing OHS and the effectiveness of the OHS role is further hindered by the lack of a clearly developed career path that can attract and retain the best OHS skilled people and offer them career development opportunities within the industry. This study suggested the need for clear career advancement path and also possible exit points for OHS practitioners

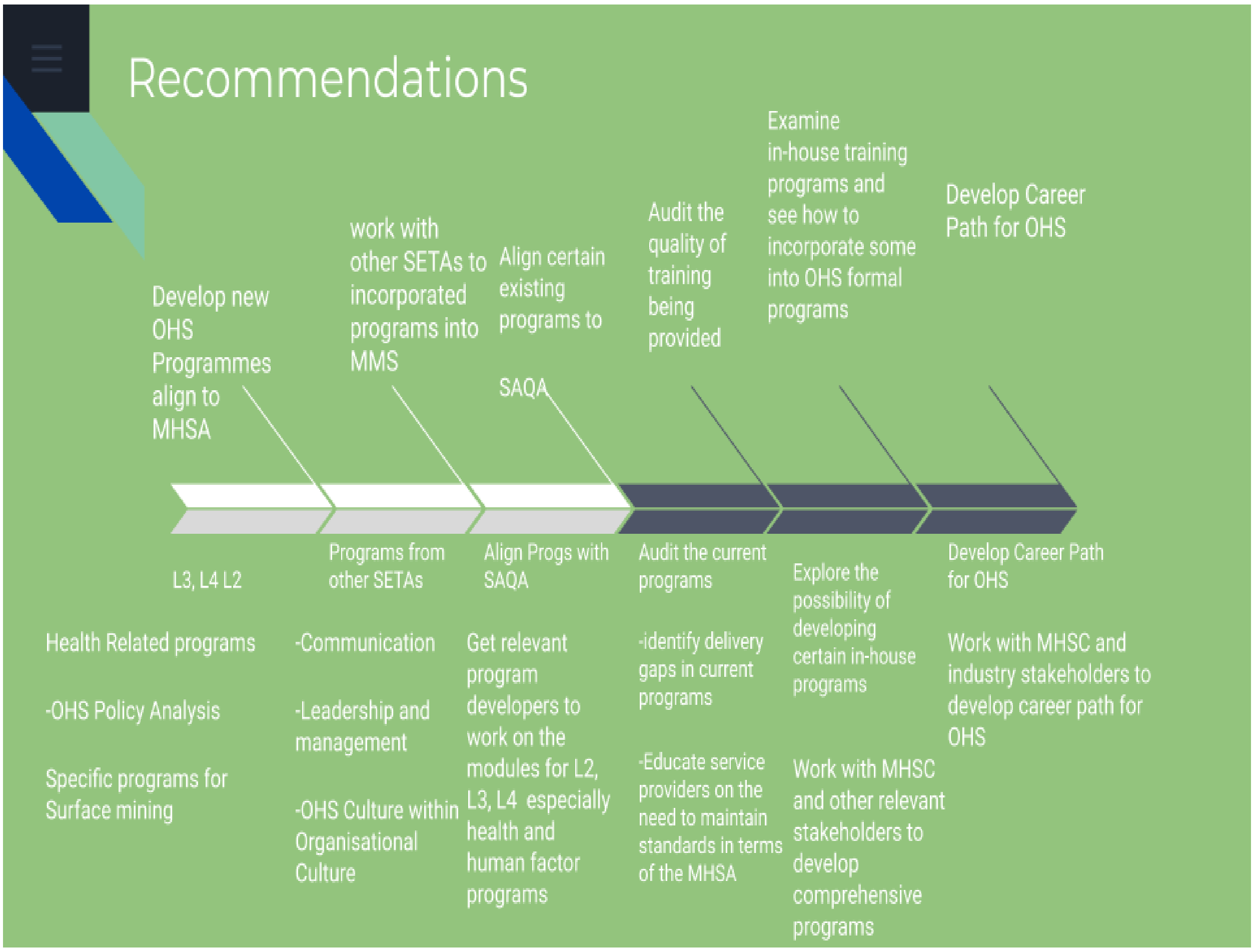


Figure 7.1 Summarises the recommendations made in this study

As shown in the Figure 7.1, there is a need for the MQA to critically consider the recommendations and enable OHS skills development in line with the MHSA and to ensure that the developed skills are transferred to the work.

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ANNEXURE A: QUESTIONNAIRE

FINAL QUESTIONNAIRE

Project title: Understanding Occupational Health and Safety needs in Mining and Minerals Sectors

1	Socio-demographic characteristics (See appendix)					
1.1	Mine Characteristics					
1.2	Respondents' Characteristics					
2	**Factors contributing to fatalities, injuries and work-related diseases in the mine**					
2.1	Major hazards in the mine	Yes [1]	No [0]	Check Hazard Register of Profile		
Q1	Chemical hazards					
Q2	Physical hazards					
Q3	Biological and psychosocial hazards					
Q4	Mechanical					
Q5	Manual handling hazards					
2.2	Fatalities, Lost Time Injuries (LTI) and work-related diseases reported in last 12 months	Number				
Q6	Number of fatalities in the last 12 months		Check Accident Investigation Register			
Q7	Number of LTI in the last 12 months		Check Accident Investigation Register			
Q8	Number of Occupational diseases reported in the last 12 months		Check Reporting of Occupational Diseases Register. (Type of disease)			
2.3	**Causes of fatalities, injuries and work-related diseases**					
2.3.1	**Primary causes**	[1] Never	[2] Less frequent	[3] Frequent	[4] Very frequent	
Q9	Explosives and fires,					
Q10	Rock bursts,					
Q11	Rock falls,					
Q12	Physical hazards					
Q13	Machinery and transport					
2.3.2	**Root (underlying) causes**	[1] Strongly disagree	[2] Disagree	[3] Undecided	[4] Agree	[5] Strongly agree
Q14	Lack of training					
Q15	Management influences (leadership)					
Q16	Unsafe supervision,					
Q17	Preconditions for unsafe acts,					
Q18	Workers' unsafe acts					
2.4	Fatality improvement interventions in the mine	Yes [1]	No [0]			
Q19	Educational and Health and safety training (including occupational health awareness programmes for workers e.g. NIHL, silicosis, TB)					
Q20	Introduction of technological innovations					
Q21	Improvements in accident investigation and reporting methods					
Q22	Visible felt leadership approaches					
Q23	Effective frontline organisation and supervisory empowerment					

2.5	Current mine H&S themes discussed in Board and H&S committee meetings	In Board meetings Yes [1] No [0]		In H&S com. Meetings Yes[1] No [0]		
Q24	Putting people first in health and safety					
Q25	Leadership as primary enabler of good health and safety performance					
Q26	Introduction of new technology and use of data					
Q27	Engagement and empowerment of frontline supervision					
Q28	Focus on safety and operational risks related to major accidents					
Q29	Collaboration and learning through sharing experience					
Q30	Integrated mining activities					
Q31	Management of contractors					
Q32	Increase Investment in Health and safety					
Q33	Frontline supervisor as a change agent in the mine					
Q34	Other (Specify)					
3	Factors influencing OHS practices in the mining workplace					
3.1	**Compliance with legal requirements & policies**	[1] Strongly disagree	[2] Disagree	[3] Undecided	[4] Agree	[5] Strongly agree
Q35	Bringing up safety issues is accepted in this organisation					
Q36	My co—workers work safely					
Q37	It is ok to remind or encourage people to work safely					
Q38	People go out of their way to help someone do a job safely					
Q39	We implement Tripartite stakeholder's policies					
Q40	Suggestion box systems operational and effective					
3.2	**Human and organisational factors**					
Q41	**Organisational safety leadership**					
Q42	Employee safety is a priority for management in this company					
Q43	My company safety goals and results are clearly communicated					
Q44	There is an expectation that work will be performed safely					
Q45	Production demands and safety conflicts are addressed properly					
Q46	Managers are concerned with my safety					
Q47	Safety performance is considered in performance appraisals and promotion					
	Safety supervision					
Q48	Supervisors are good safety role models					
Q49	It is clear my supervisor prioritizes safety concerns					

Q50	My manager provides clear feedback on my job performance					
Q51	Safety policies are enforced					
Q52	There are consequences for violating safety rules					
Q53	Supervisors have effective coaching skills that result in a safer workplace					
	Employees safety involvement					
Q54	I am comfortable raising safety issues					
Q55	My opinion is valued by my supervisor					
Q56	Leaders in this company solicit safety ideas from employees					
Q57	Leaders use safety suggestions made by employees					
Q58	Adequate safety information is shared with employees					
Q59	A team approach is valued in this company					
Q60	Our safety meetings are effective					
3.3	**Production targets vs. safety**					
Q61	Production bonuses and safety incentives are beneficial for ensuring safe work					
Q62	Safety is sometimes compromised in order to meet production targets					
Q63	The recognition given to me by incentive payment is more important to me than the payment itself					
Q64	Without bonuses and incentives, no one gets motivated here					
3.4	**Issues associated with introducing new technology**					
Q65	Workers are consulted and involved in decision-making regarding the introduction of changes in technology					
Q66	New technology makes my work easier and safer					
Q67	I feel I need some training to deal with the changes introduced by new machines and work equipment					
Q68	We have fewer accidents with the introduction of new technology					
3.5	**Training as a factor influencing OHS practice**					
Q69	Employees are effectively trained to do their job safely					
Q70	New employees are effectively trained on safety rules and procedures					
Q71	Knowledge and skills gained through safety training programs are enforced in our work practices					
Q72	Lessons learned from accident investigations are used to make our workplace safer					
Q73	I have a clear understanding of workplace hazards and how to avoid injury at work					
3.6	**Safe work environment**					
Q74	My work environment is safe					

Q75	The equipment and tools I use are safe					
Q76	I am provided with proper safety equipment					
Q77	My company properly evaluates the risk of tasks we perform					
Q78	Our work procedures are safe					
	Unsafe conditions are corrected in a timely manner					
4	**Factors influencing risk management in the mine**					
4.1	**Risk management as an issue in the mine**					
Q79	The mine maintains a Hazard Register or Risk Profile					
Q80	We focus only on human behaviour to control risks in the mine					
Q81	We combine human behaviour, technology, accident investigation and task analysis to eliminate or reduce risks in the mine					
Q82	We use lagging and leading indicators to improve health and safety performance					
Q83	Risk management is discussed in board and Safety committee meeting					
4.2	**Factors influencing risk management in the mine**					
Q84	We identify hazards and control their risks before incidents occur					
Q85	We seek to blame people when accidents are investigated here					
Q86	Production cost, bonuses and safety incentives are a powerful driver of actions onsite					
Q87	Production bonuses may encourage workers to hide incidents					
Q88	The company receives economic incentives from external sources to improve safety performance					
Q89	Workers are engaged and participate effectively in the risk management process					
4.3	**The risk management process in the mine**					
	Hazards on site are identified using:					
Q90	● Workplace inspections and statistics,					
Q91	● Job safety analysis					
Q92	● Accident and incident reports					
	We assess risks by:					
Q93	Comparing systems					
Q94	Using our judgement					
Q95	Applying the risk matrix					
Q96	We treat risks using the hierarchy of controls					
Q97	Communicating and consulting is an essential part of risk management					
Q98	The risk management process is continuously monitored and reviewed for improvement					

Q99	Development and use of a risk management practice guide for the MMS					
4.4	**Risk recognition and risk perception: factors affecting workers' ability to recognise hazards**					
Q100	Hazard recognition is a critical skill in the mine					
Q101	Hazard identification tasks are listed and workers are tested for their ability to recognise hazards					
Q102	Do you have enough influence over your work?					
Q103	Can you influence decisions about your physical working environment?					
Q104	Can you decide when to take a break?					
	I have opportunities to change anything to address health and safety					
5	**Nature of education and training interventions to support OHS practice in the mine**					
5.1	**Compliance with statutory and tripartite policy requirements for education and training in the mine**					
Q105	The employer or mine owner provides employees with information, instruction, training or supervision necessary to enable them to perform their work safely and without risk to health;					
Q106	The employer or mine owner ensures that every employee becomes familiar with workplace hazards and risks and the measures to be taken to eliminate, control and minimize those hazards and risks					
	Information, instruction, training and supervision are provided:	Yes [1]	No [0]			
Q107	(a) Before that employee first starts work;					
Q108	(b) At intervals determined by the manager after consulting the health and safety committee;					
Q109	(c) Before significant changes are introduced to procedures, mining and ventilation layouts, mining methods, plant or equipment and material; and					
Q110	(d) Before significant changes are made to the nature of that employee's occupation or work.					
Q111	Induction and refresher training is designed for all ranks of mine workers					
Q112	ABET is a primary intervention for health and safety in the mine					
5.2	**Key change drivers shaping skills development in the mine**					
Q113	Mine is integrating advanced technology in the mining process					
Q114	Skills development programmes for workers to progress towards advanced technological operations					

Q115	Skills development to deal with new hazards					
Q116	Introduction of new technology in our mining workplace require some retrenchments					
5.3	**Nature of OHS training programmes in the mine**	Yes [1]	No [0]			
Q117	Integrative training (combining self-protection and risk avoidance to fellow workers and others)					
Q118	Induction and refresher training to all ranks of mine workers					
Q119	ABET and OHS representative training					
Q120	Training for underserved workers and people with disability					
Q121	Training for ageing mine workforce					
Q122	Train-the-trainers programmes					
Q123	Other educational programmes					
5.4	**Perceptions about education and training**	[1] Strongly disagree	[2] Disagree	[3] undecided	[4] Agree	[5] Strongly agree
Q124	In-house or on-the-job training is more effective than outside training					
Q125	Attendance of ABET in the mine (very high, high, moderate, low, very low)					
Q126	Attendance of MQA OHS representative skills programme in the last 2 years					
Q127	ABET has helped to reduce accidents and incidents in the mine					
Q128	ABET should lead to career progression					
	Mine should focus on employee training and development through: learnerships, bursaries, portable skills, internships					
5.5	**Effectiveness of OHS training programmes in the mine**	Yes [1]	No [0]			
Q129	Training needs assessments are undertaken					
Q130	Training objectives are specified in training programmes					
Q131	Individual differences or special needs are accounted for in planning and delivering training					
Q132	Training manuals, guides, workbooks are produced and used					
Q133	Effectiveness surveys are conducted					
5.6	**Skills shortages in the mine**					
Q134	Leadership and managerial skills (senior management)	Yes [1]	No [0]	Priority		
Q135	People, supervisory and communication skills (technicians and artisans)					
Q136	Knowledge and application of new technology (technicians and artisans)					
Q137	Computer and numeracy skills (lower level employees)					

Q138	Other (specify					
5.7	Skills required to deal with OHS issues					
Q139	To deal with issues of Fall of ground and fall of rocks we need skills to identify geological anomalies that could pose hazards in our mines	Yes [1]	No [0]	Priority		
Q140	We need skills on the use of safety nets					
Q141	We need skills on baring procedures					
Q412	We need for pre-entry examination					
Q143	In order to deal with underground rails and locomotives, we need skills 1. implementation of Compulsory Codes of Good practices rail bound transport 2. procedures for underground rail systems to improve safety 3. locomotive operators training on loading, safety zone etc.					
Q144	We need skilled operators of trackless mobile machines operations					
Q145	We need skills in noise monitoring, testing and reduction					
Q146	We need skills in air quality monitoring, testing and reduction					
Q147	We need skills in risks management					
Q148	We need skills in OHS leadership and management					
Q149	We need skills to monitor heat in our mine					
Q150	We need skills to monitor the use of personal protective equipment					
Q151	We need skills on the use of new mining equipment and technology					
Q152	We need skills to monitor and analyse ergonomics factors such as vibrations, postures					

APPENDIX TO QUESTIONNAIRE FINAL

Project title: Understanding Occupational Health and Safety needs in Mining and Minerals Sector

Socio-demographic characteristics and document review

Mine characteristics

1. **Commodity group**
   Indicate your type of MMS sub-Sector or stakeholder group that you are

Coal Mining	
Gold Mining	
Platinum Group Metals (PGM) Mining	
Diamond Mining	
Other Mining	
Cement, Lime, Aggregates and Sand (CLAS)	
Services Incidental to Mining	
Diamond Processing	
Jewellery Manufacturing	

2. **Site location**

3. **Ownership of site**

4. **Type of mining**

   a) Open cast [ ]
   b) Underground [ ]
   c) Mixed [ ]

5. **Employee numbers (direct and contractor)**

   a) Direct...........
   b) Contractor........

6. **Numbers of fatalities and injuries and occupational diseases**

   a) Fatalities.............
   b) Lost-time injuries..............
   c) Occupational diseases reported.................

7. **Age of mine...............**

   (Use the mine number as a proxy for age, since this number has been allocated sequentially as mines begins operations (i.e. Lower mine numbers indicate an older mine).

8. Respondents (participants in FGDs and interview):

a) The most senior manager on site
b) The OHS manager and practitioners
c) Health and safety representatives
d) Technical specialists
e) HR manager and practitioners
f) Managers/supervisors at different levels
g) Artisans
h) Mine workers and equipment operators

9. Age, sex, marital status, job position, employment type, education, work experience

9.1 Please indicate your gender

Female	
Male	

9.2 Please indicate your age group

18 - 35	
36 - 45	
46 - 55	
56 - 65	
Above 65	

9.3 Please indicate your highest educational level

Primary School	
High School/College	
Diploma	
Degree	
Post graduate degree	
Other (Specify)	

9.4 Please indicate your position in your organisation

Mine Manager	
Health and Safety Inspector	
Skills development service provider	
Miner	
Union Leader	
Other (Please Specify)	

9.5 Number of years you have been in this role

Less than 5 years	
6 to 10 years	
11 to 20 years	
More than 20 years	

Document review

1) Organisation and employment profile of the site – the organisational structure, how many people and in what occupational/functional groups.
2) Reports or documents outlining any OHS improvement strategies or programs undertaken.
3) Reports or documents outlining any organisational culture improvement strategies or programs undertaken.
4) Any reports on organisational change or change management.
5) Any local or specific industrial agreements or arrangements.
6) Documentation of any production bonus and safety incentives schemes.
7) Incident records and analyses.
8) Investigation reports.
9) Performance reports.
10) OHS Management System documents setting out the formal system.
11) Audit reports.
12) Terms of reference and other records of OHS consultative arrangements (e.g. recent minutes of OHS committees).
13) Any evaluations of any of these systems/processes.
14) Inspectors' reports.
15) Shift arrangements.
16) Employee Assistance Programme report/data.
17) Annual reports.