Exploring systemic interventions on the safety performance of gold mines in Gauteng

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DECLARATION

I hereby declare that the mini-dissertation submitted herewith to North-West University in partial fulfilment of the requirements Master of Business Administration (MBA) degree is my own original work. It has been edited in accordance with professional communication standards and has not been previously submitted to any other institution for evaluation.

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01 November 2025

DEDICATION

This mini-dissertation is dedicated to all the individuals involved in the mining industry who have contributed to its development and are central to the improvements seen.

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ABSTRACT

Safety in South-African gold mines remains a critical concern with serious concerns persisting despite ongoing safety initiatives.. This study explores systemic interventions within a Gauteng gold mine. An interpretivist paradigm underpins the research which a qualitative case study approach. Primary data collection involved semi-structured interviews with eight senior managers involved in these interventions. Thematic analysis identified key themes aligned with the research objectives. ATLAS.ti facilitated data analysis and coding of themes. Findings showed that safety challenges include both systemic and behavioural issues, such as operating and equipment constraints, environmental conditions, employee behaviour and wellbeing, culture, leadership and gender inclusivity gaps. Interventions included risk identification and mitigation systems, competency development, management and behavioural reinforcement and integration procedural and technological innovations. The most impactful interventions combined systemic and human-centred approaches. The study recommends that a safety framework incorporate zero harm as a core strategy, include robust risk management with employee input, leverage automation and technology, incentivise safety performance, and enhance education, awareness, and responsibility. Integrating systemic and humanistic approaches supported by technology offers a pathway for safety improvement and contributes to safer gold mining operations. The study expands systems theory in a high-risk mining environment by showing how integrated interventions may influence safety and operational outcomes. Practically, the findings offer guidance to mining operations to enhance safety performance.

Keywords: Mining Industry; Safety performance; Safety Culture; Sustainability; Systemic Interventions; Systems Theory; Qualitative Study; Zero Harm

ABBREVIATION LIST

DMRE	Department of Mineral Resources and Energy
ESG	Environmental, Social and Governance
FOG	Falls of ground
FY	Financial Year
GDP	Gross Domestic Product
ISO	International Organisation for Standardisation
MOSH	Mine Occupational Safety and Health
R&D	Research and Development

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CHAPTER 1 INTRODUCTION

1.1. INTRODUCTION

The gold mining industry is unique in South Africa and characterised by numerous shafts approaching the end of their operational life. Despite this, the gold mining industry still significantly contributes to employment and GDP in the country despite facing numerous operational challenges, including the risk of mine closure due to declining reserves and operational and safety issues (PriceWaterhouseCoopers, 2023, p. 5). This is especially true for deep-level gold mines, which incur substantial operating costs and confront complex safety management challenges due to the inherent risks involved (De Jager, 2019, p. 334).

Adding to this complexity is the issue of unemployment within South Africa. Gold mining and its economic subsystems employ approximately 90,000 people in the country (Minerals Council South Africa, 2022, p. 44). As such, efforts should be made to protect and prolong this industry and the livelihoods it creates. The socioeconomic impact of this industry cannot be understated (Minerals Council South Africa, 2022, p. 44). With a few notable exceptions, capital investment in these shafts is limited, and the adoption of new technology is constrained by cash flow issues or considerations related to the end-of-life (PriceWaterhouseCoopers, 2023, p. 5). Attention must be directed toward enhancing operational efficiency and safety performance of the operations within the existing framework and leveraging this through systemic interventions.

Tremendous strides have been made in the safety performance of operating mines on the journey toward what is referred to as “Zero Harm”. However, a considerable number of fatal incidents still occur in the mining industry, particularly in gold mining. The regression in safety performance in 2023 underscores the need for further efforts to achieve this goal (Minerals Council South Africa, 2024). While gold mines have made safety improvements, the objective of zero harm remains unfulfilled. To ensure the long-term sustainability of this industry, further efforts are required to enhance the operational efficiency and safety performance of these operations.

Achieving these targets, however, is not straightforward. The mining industry is characterised by its unique challenges. Labour-intensive and deep-level operations can be fraught with operational challenges and labour issues (Minerals Council South Africa, 2022, p. 42). A multifaceted approach will be necessary to address this issue.

The above conditions within the South African mining industry are also contextualised within Gauteng (PriceWaterhouseCoopers, 2023, p. 5). The bulk of reserves in Gauteng is consolidated within one operation, but there exists potential for operations to convert resources to reserves (PriceWaterhouseCoopers, 2023, p. 5). The key to doing so will be to overcome the challenges posed to the industry. The study aims to conduct a case study examining the implementation of systemic interventions and the effect on safety performance of a gold mine in Gauteng. A case study on [Mine A] can capture these challenges, along with the influence of systemic interventions.

The operating and safety performance of [Mine A] in Gauteng is indicative of the abovementioned challenges. The operation currently has a short-term life of mine. The higher gold price can provide a potential addition to this by creating favourable market conditions. However, the safety and production performance experienced in the 2022 and 2023 financial years could harm the operation's investment case. An untimely closure will hurt the province's socio-economic conditions. In the current context, systemic interventions have been implemented at this operation during the 2023 and 2024 financial years (FY23 and FY24), to achieve a turnaround in productivity and safety performance. This provides a unique setting for conducting a case study, allowing senior management involved in these interventions to effectively articulate the influence of the interventions both before and after implementation from their perspective. These perceptions are key to understanding the phenomena of the case.

Studies have been conducted on the mining industry to assess the extent and success of the wide range of systemic interventions in improving either efficiency or safety performance (De Jager, 2019; Neingo & Tholana, 2016; Pillay et al., 2010; Sundström & Nygren, 2023b; Tetzlaff et al., 2021). These interventions are typically examined in isolation from one another, which may potentially limit their effectiveness. Meanwhile, there is a dearth of studies regarding the context of deep-level gold mines and the influence of a holistic approach to these interventions. Where systemic interventions have been introduced in an operation, the development, implementation, and

adaptation will be explored through the perceptions of those involved. Focusing on the design, implementation, and adaptation also provides context for implementing strategic management.

1.2. PROBLEM STATEMENT

Significant improvements have been made in the safety and operating efficiencies of gold mines in South Africa (Minerals Council South Africa, 2024). Despite progress, serious and fatal injuries still occur at unacceptable levels, indicating that zero harm is an aspirational target with current safety systems and interventions (De Jager, 2019, p. 321). These challenges are compounded by aging infrastructure, limited capital expenditure and operational pressures. Despite these operational challenges, gold mining remains a key contributor to employment and community welfare in South Africa (Minerals Council South Africa, 2022, p. 44).

Urgent action is however required to address operations' safety and operational concerns (De Jager, 2019, p. 321; Neingo & Tholana, 2016; PriceWaterhouseCoopers, 2023). An operation compromising safety cannot fulfil its social license to mine (De Jager, 2019, p. 321). This is fundamental to achieving sustainability in the gold mining industry, as it is both a moral and business imperative. Operating models of mines must ensure that its value proposition aligns relationships with stakeholders and shareholders across economic, socio-political, and moral aspects (Mathibe, 2011, p. 2). Mining operations must balance profitability with improving social and environmental outcomes, such as safety and employee well-being (Mathibe, 2011, p. 2). With this social license imperative unfulfilled, mines will not be allowed to operate, which will be detrimental to the stakeholders of gold mining. These include i) employees and contractors through direct employment, ii) added value through supply chains, and iii) the socioeconomic conditions of the surrounding communities.

Efforts to improve safe and sustainable mining operations should thus be considered. Understanding the influence of designing, implementing, and adapting systemic interventions on safety performance can lead to improvements, helping fulfil the social license to mine and preventing premature mine closures. This study adds to literature in the South-African context through a case study, provides guidance for practical implementation and extends systems theory to systemic interventions in gold mining.

1.3. RESEARCH QUESTIONS

In achieving the clearly stated research aim and objectives, the following questions need to be addressed:

i. What are the major challenges regarding the safety of the employees during mining?
ii. What are the systemic interventions adopted during the mining operations?
iii. What key aspects of systemic interventions should be considered as influences on safety?
iv. What adoptable framework can be inserted to enact an overall safety performance?

1.4. AIM AND OBJECTIVES OF THE STUDY

1.4.1. Primary objective

This study examines the systemic interventions implemented in Gauteng gold mines and their effect on safety performance.

1.4.2. Secondary objective

The objectives can be summarised as follows:

i. To identify the main challenges related to employee safety during mining
ii. To reveal the systemic interventions implemented during mining operations
iii. To explore the aspects of systemic interventions that affect the safety of mining operations
iv. To establish a framework for overall safety performance

1.5. RATIONALE AND SIGNIFICANCE OF THE STUDY

The aim of this study is to examine how systemic interventions influence safety performance in a Gauteng gold mine, as perceived by individuals involved in designing, implementing, and adapting these interventions. The study also identifies and analyses the development, implementation, and adaptation of these interventions through document analysis. Unlike previous research that often considers interventions in

isolation, this study explores their combined influence within an operational mining environment.

The findings will support managers and policymakers in understanding how systemic interventions affect both safety and operational performance, enabling the development of more effective strategies that enhance productivity, profitability, and workplace safety. By examining the complexities of intervention design and execution in a high-risk sector, the study contributes to industry knowledge and informs best-practice frameworks for targeted implementation.

Safe and efficient mining operations also align with broader societal goals, particularly Sustainable Development Goal 8, which promotes safe working conditions, productive employment, and sustainable economic growth. Improved safety performance supports community well-being, sustained employment, and poverty reduction by ensuring the continued viability of mining operations.

1.6. RESEARCH OUTLINE

- Chapter 1— Introduction. This chapter introduces the study to be conducted, including its aim, objectives and contribution.
- Chapter 2 – Literature Review. This section focuses on the literature review required for the study, split amongst conceptual, theoretical and empirical sections.
- Chapter 3 – Methodology. This outlines the methodology for the research.
- Chapter 4 – Data Collection and Results. This chapter analyses and discusses the study's results.
- Chapter 5 — Conclusion, Limitations, and Recommendations. This chapter concludes the study and offers recommendations for future research and suggestions for addressing limitations.

CHAPTER 2 LITERATURE REVIEW

The gold mining industry in South Africa has been subjected to enhanced focus to arrest declining productivity levels (Neingo & Tholana, 2016, p. 429). In addition to trying to address the slide in productivity, renewed emphasis has been placed on improving safety conditions in underground operations and achieving the stated goal of zero harm (Joughin, 2024, p. vi). Significant achievements have been realised regarding systemic achievements to reduce the fall of ground events, which are one of the leading risks associated with deep-level gold mining (Joughin, 2024, p. vi).

The industry's focus has been guided by strategic management principles grounded in research to achieve these objectives. With the numerous challenges that face the gold mining industry, methods to achieve the stated targets and ensure the sustainability of the chosen interventions are imperative.

Industry-wide interventions have focused on both systemic and humanistic aspects. Examples of safety being focused on at a systemic level include adopting the Mine Operational Health and Safety (MOSH) leading practice, which shifted the focus to leading indicators to address safety risks (Hermanus et al., 2015, p. 718). This aims to focus on the uptake of leading practices to address health and safety priorities (Hermanus et al., 2015, p. 718). It also focuses on the use of technology and processes to achieve these improvements (Hermanus et al., 2015, p. 718).

There are also well-known examples of humanistic interventions in the industry that can be identified, such as the focus on leadership, behavioural-based campaigns, and the facilitation of the development of a safety culture (De Jager, 2019, p. 121). These interventions are aimed at reducing the occurrence of safety incidents.

Despite the numerous interventions in the industry, some operations experience challenges related to safety and productivity. The key to understanding why this is the case is to understand the nuances of the operation and how the interventions are implemented.

In the context of Mine [A], the approach to systemic interventions was guided by the overarching company strategy. However, renewed focus is required on the operation,

guided by strategic management principles to identify gaps and generate interventions that will enable the operation to address its challenges.

2.1. CONCEPTUAL REVIEW

The conceptual review is structured to outline key concepts and constructs within the study conducted. The key concepts outlined are as follows:

2.1.1. Overview of the gold mining industry in South Africa

The gold mining industry has a storied history in South Africa, with gold mining spanning more than a century (Mutele & Carranza, 2024, p. 1). During the last decade, the industry has contributed an average of 8,7% to GDP, despite a reduction in gold produced per annum (Mutele & Carranza, 2024, p. 1).

The gold mining industry in South Africa is characterised by declining production (Mutele & Carranza, 2024, p. 1). Once one of the world's largest producers of gold, as of 2023 South Africa occupied eleventh place in the global gold producers, accounting for around 3% of global gold production (Global Data, 2025).

The average production per annum is outlined in Figure 2.1 below:

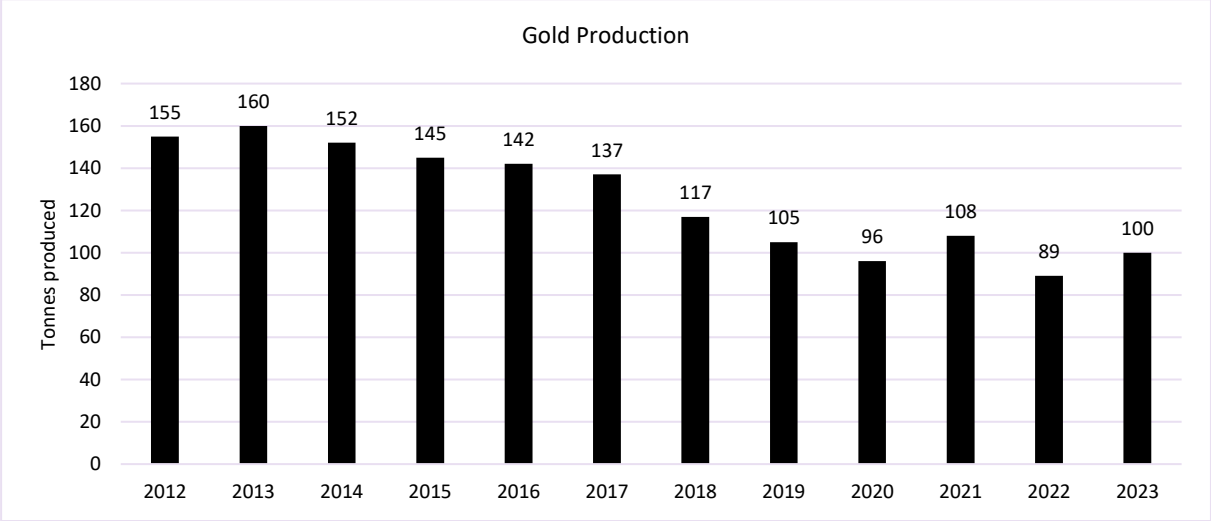

Figure 2-1 - Annual gold production in South Africa

Source: CEIC Gold Production in South Africa (CEIC)

Employment trends mirror the declining production profile, illustrated in the trend in Figure 2.2 below:

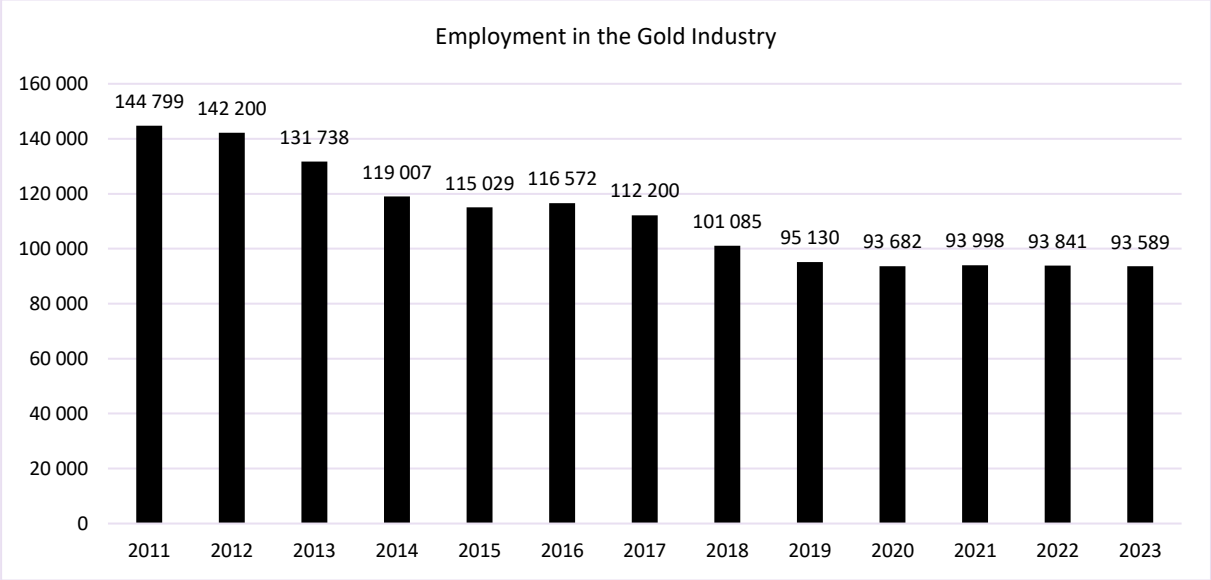

Figure 2-2 - Annual employment in the gold industry in South Africa

Source: Statista, Employment in the gold industry (Statista)

Both these trends are indicative of the declining industry and serve to highlight how the preservation of the industry is imperative through improved operating efficiency and safety performance, with the bulk of reserves at lower depths than what the current operations are mining at (PriceWaterhouseCoopers, 2023, p. 5).

2.1.2. Overview of the gold mining industry in Gauteng

The gold mining industry in Gauteng is indicative of the South African situation. The majority of gold mines are located in the west rand, with the Witwatersrand basin still containing the world's largest gold reserves (Minerals Council South Africa, 2025).

The Gauteng province accounts for roughly 84% of the gold reserves in South Africa (PriceWaterhouseCoopers, 2023, p. 5). The caveat to this is that roughly 55% of this number sits at one operation (PriceWaterhouseCoopers, 2023, p. 5).

There are currently ten gold mining operations in Gauteng as at 2023, providing roughly 61% of the gold production in South Africa (PriceWaterhouseCoopers, 2023, p. 5). These operations are owned by various companies including Harmony Gold,

Sibanye-Stillwater, Goldfields and Pan African Resources (Minerals Council South Africa, 2025). These gold mines are classified as deep-level underground gold mines.

These gold mines are depicted below in Figure 2.3:

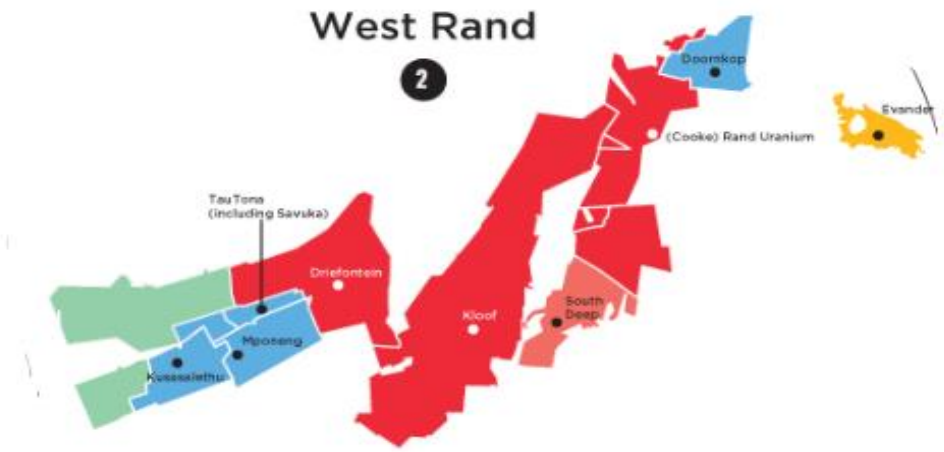

Figure 2-3 - Gold Mines in Gauteng

Source: Minerals Council of South Africa (Minerals Council South Africa, 2025)

2.1.3. Safety and operating performance

Safety performance encompasses the frequency and severity of injuries reported at the mining operation. The frequency of injuries is referred to as a lagging indicator, as it occurs after the event.

Leading indicators are figures used to show the potential for injuries to occur and are typically measurements from risk management systems.

Operational performance refers to the overall performance of an operation, with an emphasis on reported production parameters (Olaleye, 2017). This study's perspective also expands to include financial performance in terms of revenue and cashflow generation for an operation (Akinola et al., 2022).

2.1.4. Safety and productivity of the South African gold mining industry

Safety in the gold mining industry has made great strides in the reduction of loss of life events. In the 2024 calendar year, the gold mining industry in South Africa recorded eleven losses of life, in comparison to twenty in 2023 (South African Government, 2025). The historical performance is reflected below in Figure 2.4:

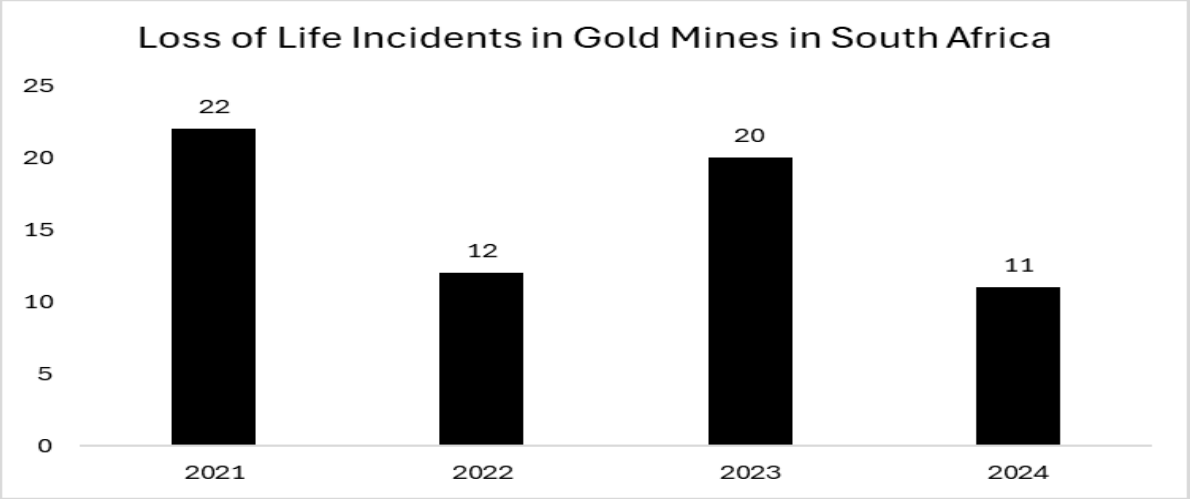

Figure 2-4 - Loss of life statistics in South African gold mines

Source: DMRE (South African Government, 2025)

Whilst this represents a significant improvement year on year, the focus is on achieving zero harm, which was a stated objective of the mineral's council through mining CEO's. The focus was on achieving this as at the end of the 2024 calendar year. A notable number of injuries occurred during mining operations, with the highlighting of the number of repeat incidents as a concern (South African Government, 2025). The most significant improvements made in the industry related to fall of ground type events and those involving machinery (South African Government, 2025).

Productivity in the gold mining industry has continued to decline in recent years (Pelders et al., 2021, p. 429). These factors are attributable to i) increased depth at which mining activities are conducted, ii) increased travelling distances to and from working places and iii) increased safety requirements with an example being the installation of steel netting (Pelders et al., 2021, p. 429).

2.1.5. Factors relating to the causes of safety incidents in gold mining

Many hazards are associated with the mining industry. These encompass a wide range that can be classified according to different categories. Baghaei Naeini and Badri (2024, p. 7) identified numerous categories and agencies associated with injuries in the mining industry. These included i) chemical agents, ii) physical agents, iii) biological agents iv) Ergonomic, v) Accidents vi) and psychological effects (Baghaei Naeini & Badri, 2024, p. 8).

In terms of accidents, the main agencies identified are i) Fire, ii) falls from heights, iii) falling rocks, iv) flooding v) electrocution vi) abrasives from rotating parts and vii) drawing in or trapping hazards (Baghaei Naeini & Badri, 2024, p. 8).

In South Africa, whilst improvements have been made in addressing the loss of life-related incidents in the mining industry, there are still numerous occupational injuries that occur (South African Government, 2025).

The most notable contributors to occupational injuries as per the South African Government (through the Department of Minerals and Energy) are listed as:

- Fall of ground injuries
- Transportation injuries, which are derived from the transport of men, material and ore via shaft conveyances (vertical) and locomotives (horizontal).
- General injuries

Due to the nature of the injuries, the advice provided to the industry was to ensure that all employers and employees are explicit about their respective roles and programmes that are in place to ensure the provision of a safe working environment (South African Government, 2025).

In addition to the injuries incurred, the gold mining sector also recorded the highest rate of occupational diseases relating to both silicosis and pulmonary tuberculosis (South African Government, 2025).

These instances further highlight the need for improved working environments at the gold mining operations in South Africa and highlights how the focus on safety needs to incorporate the wellness element.

2.1.6. Legislation

Whilst there have been numerous safety incidents that have occurred in the mining industry, extensive legislation has been put in place in South Africa to govern mining activities.

The primary legislation governing the mining industry is the Mine Health and Safety Act No.29 of 1996. The primary purpose of the legislation is to safeguard the health and safety of employees whilst conducting mining activities. It confers rights and responsibilities to employees and employers. The legislation provides a basis for establishing risk management systems, whilst also providing measures to monitor and enforce compliance. Section 22 and 23 also prescribe the importance of employee participation in health and safety matters and affords them the right to withdraw from any unsafe working conditions (Mine Health and Safety Act 29, 1996).

2.1.7. Industry frameworks adopted for improved safety outcomes

An important point to elaborate on is the industry frameworks that are adopted to drive operational safety performance in the mining industry. These are wide ranging frameworks that assist to ensure that improved safety outcomes are achieved.

The main frameworks that are applicable to industry that will be discussed are:

- International Organisation for Standardisation (ISO) certification, which is a global standard that can be implemented.
- Mining Industry Occupational Safety and Health (MOSH) adoption, which is applicable to South Africa.
- The Khumbul'ekhaya health and safety strategy which is central to strategy in South African mining operations.

These three frameworks are outlined below:

ISO Certification

A commonly used framework within the mining industry for safety performance is the implementation and accreditation of ISO Standards (Nygren & Sundström, 2025, p. 2).

This is typically the OHSAS18001 certification, which is related to the management of health and safety standards and was superseded by ISO 45001.

Achieving ISO certification is a manner to ensure that a compliance framework and relevant safety measures are in place to provide a conducive work environment.

MOSH Adoption

The Mine Occupational Safety and Health leading practice adoption system is focused on the uptake of leading practices to ensure that health and safety are prioritised, with the usage of technology and procedures facilitating the improvements (Hermanus et al., 2015, p. 718).

The practices, developed in 2013, were aimed at addressing key areas such as i) falls of ground, ii) transport and machinery which were relevant to mine losses of life, iii) dust and iv) noise, with relevance in these areas to silicosis and noise loss from mining activities (Hermanus et al., 2015, p. 718).

The purpose of the leading practices adoption was to identify leading practices at source mining operations, documenting these areas, piloting them in another operational mine and then eventually promoting the practice for adoption within the industry if proven (Hermanus et al., 2015, p. 718).

The adoption of leading practices has been proven to offer health and safety hazard mitigation (Hermanus et al., 2015, p. 718).

Khumbul’ekhaya

The Khumbul’ekhaya health and safety strategy emerged from the mining industry’s pursuit of zero harm and is driven through the industry’s CEO zero harm forum (Minerals Council South Africa, 2023, p. 2).

The focus of this strategy is to introduce a targeted approach to reduce fatalities in the mining industry in South Africa. This targeted approach is aimed at the most pressing causes of industry fatalities (Minerals Council South Africa, 2023, p. 2).

Three specific projects were approved in 2021 to be implemented to improve safety outcomes in the mining industry namely i) Culture transformation, ii) Tripartite

stakeholder engagement and iii) the digitisation of safety data (Minerals Council South Africa, 2023, p. 2).

Culture transformation, with a particular focus on risk management, encompasses the introduction of a just culture framework and a multi-disciplinary peer review of incidents, coupled with improved accident investigation systems and analysis. These measures were implemented to ensure that learnings are provided from safety incidents that the industry could use to ensure that repeats do not occur (Minerals Council South Africa, 2023, p. 2).

Tripartite stakeholder engagement is focused on ensuring collaboration and alignment in achieving safety targets. The tri-partite includes key stakeholders such as the DMRE, labour organisations and industry stakeholders (Minerals Council South Africa, 2023, p. 3). The tri-partite engagement has led to critical interventions being introduced to industry including the fall of ground action plan, the development of collision avoidance systems, COVID-19 vaccination plans and the implementation of guidelines for the use of trackless machinery. In addition to this, the tri-partite engagement focuses on improving safety performance in general (Minerals Council South Africa, 2023, p. 3).

The third leg is the digitisation of safety data. This is to ensure that there is an efficient database in place to drive safety related decision making and facilitate learnings from safety incidents (Minerals Council South Africa, 2023, p. 3).

A multi-faceted approach to safety frameworks is recommended, with findings showing that a singular approach may not be sufficient (Nygren & Sundström, 2025, p. 14).

The above proposals of safety management, particularly in the South African context, showcase how the integration of systemic and humanistic elements is grounded in strategy at a CEO level within the mining industry. Furthermore, a multifaceted and engaged approach is recommended to be followed in the industry.

However with the stated objectives of zero harm not being achieved in 2024 and the high rate of injuries that are still being incurred, findings that proactive safety practices may be eroded by organisational conditions such as lack of organisational clarity or

ineffective control actions provide pause for thought (Nygren & Sundström, 2025, p. 14).

This concept is important to the context of the study as it can highlight how a certain case may require additional interventions even in the presence of an overarching pro-active safety strategy due to the conditions encountered at that operation.

2.1.8. Strategic management and its role in the design of strategic interventions

At their core systemic and humanistic interventions are strategic in nature. The interventions aim to improve current processes and develop sustainable solutions to operational challenges. It involves the translating of inputs into outputs via the use of strategy. As such, these interventions need to be carefully identified, considered, and implemented in the operating context of the organisation. The random identification and implementation of interventions will not be of benefit to any organisation.

For any systemic or humanistic intervention to be successful, it needs to be grounded in strategic management.

Strategy is defined as the set of co-ordinated activities that managers take in order to ensure the outperformance of competitors and the achievement of superior profitability (Thompson et al., 2024, p. 4). It is not based on the short term, but rather the focus is on achieving long lasting success that will support growth and organisational sustainability (Thompson et al., 2024, p. 4).

Strategic management in the context of the mining industry has its own nuances. The building block for strategic management is strategic planning, which the mining industry has been criticised for.

Contributing to the criticism is the unpredictability of the industry (Gray et al., 2024, p. 3). Unpredictability in the industry is driven by factors such as various supply chain and labour disruptions, communication barriers as well as policy reviews and adjustments that may impact on normal operational activities (Gray et al., 2024, p. 3).

Drawbacks in terms of strategic planning in mining operations have been identified to relate to i) an absence of committed strategies, ii) the focus typically being production

driven and iii) the barriers to implementation of strategic planning or imperatives (Gray et al., 2024, p. 9).

Gray et al. (2024, pp. 9-10) provide insight as to how these drawbacks can be expanded upon as follows:

1) Absence of committed strategies – this is typically due to the adoption of industry wide practices without implementing performance monitoring and management alongside the adoption of the chosen strategy. Compounding this can be the lack of strategic reviews within an organisation, with the integration of employees into this process also lacking.
2) Focus typically being on production – while there is an appreciation from industry that the strategic approach is complex and multi-faceted, the focal point is usually based on the production of an operation.
3) Barriers identified to implementation include cost effectiveness of approaches, regulatory barriers, workforce relations and an overreliance on spreadsheet-based information.

The mitigation of these concerns should be key for a strategic intervention that is considered at any mining operation in South Africa.

According to Thompson et al. (2024, p. 22) the creation of company strategy is an ongoing process that focuses on the following aspects:

1) The creation of a strategic vision. This entails the long-term direction that the organisation wants to go in. It is grounded by a mission statement and guided by a set of core values that guide the pursuit of this.
2) Setting objectives. This ensures that progress is measured and tracked to ensure that it is moving in the right direction.
3) Crafting a strategy for advancing the organisation along the path management has laid out and ensuring the achievement of its stated objectives.
4) Execution of the chosen strategy.
5) Monitoring of developments, performance evaluation and the initiation of corrective adjustments. This entails that the objectives of the strategy are achieved, but cognisance is given to the nuances that can occur in strategy

execution with new information that comes to light, and the flexibility to adapt to this.

The development of systemic and humanistic interventions is strategic at its core, with the emphasis in the mining industry focused on safety and productivity. The identification of areas where interventions are required needs to be done in accordance with gaps that are identified as well as the overarching vision and strategy of the organisation. The dual focus also ensures that the strategic imperatives are not focused on in isolation, but that the drawbacks that have been aimed at the mining industry are considered and countered throughout the process of implementation.

In terms of the hierarchical levels of strategy, Thompson et al. (2024, p. 38) prescribe four different levels. These are:

1) Corporate strategy, which is determined by the Executive level and is relevant for the organisation.
2) Business Strategy which is the strategy for each of the businesses that the organisation has diversified into.
3) Functional Strategy which is the management of activities within a business to support the business strategy.
4) Operating Strategies which is the management of activities within a functional area.

As outlined above, an overarching company strategy can be in place, but however as is the case with [Mine A], a separate more focused business strategy can be used to place more emphasis on lagging areas to ensure profitability, safety, and sustainability of the operation in line with corporate objectives. The fulfilment of these objectives is imperative for the operation to maintain the social license to mine.

2.1.9. Change management process

For any strategy, intervention or framework to be implemented, there needs to be change that is incurred and the process of this change managed. In the absence of this, it is unlikely that any strategy or intervention will be successful.

Change management in the work environment can be succinctly put as dealing with the implementation of strategies, structures, procedures and technology to cope with

change from internal and external factors. This is typically the approach used by companies when undergoing a shift in vision or goal for the future (Laig & Abocejo, 2021, p. 34).

Various frameworks exist with regards to change management, but there is consensus that is order for change management to be successful, it needs to follow a logical and structured process (Saetren & Laumann, 2017, p. 2).

According to Kotter (1996), the following eight steps can be utilised to ensure that there is effective change management:

1. Creating a sense of urgency
2. Building a guiding coalition
3. Creating a strategic vision
4. Initiate change communication
5. Removing barriers to change
6. Generating short term wins
7. Making change a continuous process
8. Incorporating changes into the organisational culture

2.1.10. Systemic and organisational culture development

Systemic development – The operational definition includes i) strategy, ii) structures, iii) policies, iv) procedures, and v) systems and processes that are put in place to advance operational efficiency and safety performance.

Organisational culture development – the operational definition refers to i) culture, ii) leadership, iii) value orientation, iv) workforce engagement, and iv) individual and team wellness initiatives that are put in place to advance operational efficiency and safety performance.

These two key aspects are illustrated in theory by the focus placed on “systemising activities to achieve zero harm” and to “humanise the safety response,” as proposed by De Jager (2019).

The systemisation of activities to achieve zero harm refers to the prevention of accidents through a framework that takes into account the current operating

environment as well as uncontrolled developing conditions that need to be taken into account (De Jager, 2019, p. 152). The complexity of safe mining needs to be systemised to consider intellectual capital and know-how (De Jager, 2019, p. 152).

Systems are based on a company's vision, mission values, and policies, and they have long-term consequences for the sustainability of an organisation (De Jager, 2019, p. 152). Standards and procedures are also defined by the organisation's overall strategy (De Jager, 2019, p. 152). These critical aspects link to the operational definition by highlighting how important i) strategy, ii) structures, iii) policies, iv) procedures, v) systems and processes are, and how they interlink with each other to drive improvement in safety and operating performance.

Adding to the systemic base is to “humanise the safety response.” This refers to transferring the safety knowledge generated and establishing the correct behaviour amongst employees to enable the achievement of zero harm (De Jager, 2019, p. 180).

Safety culture is critical to this, with leadership being a core construct through vision, example setting, and actions undertaken (De Jager, 2019, p. 180). This can be directed by systems, policies, risk responses, and the behaviour of employees (De Jager, 2019, p. 180).

The elimination of at-risk behaviour can be achieved through communication, which is a key form of engagement, focusing on empowering employees to take responsibility and to value caring for others (De Jager, 2019, p. 182).

These key aspects underline how the operational definition is supported within theory, and how the active focus on this can assist in achieving safe and efficient operations.

2.1.11. Systemic interventions

Systemic interventions are aimed at addressing issues within the overall operation's system and influencing miners' health. This includes processes related to i) infrastructure, ii) equipment, and iii) environmental conditions at the operation. Using systems theory as the dominant framework, this recognises that these various components are interrelated and that changes in one area influence those in another. The foundation of this approach lies in the strategy employed to achieve it, as well as in how this strategy is integrated into operational routines. In the mining environment

this entails that it ensures that the work environment is conducive to safe and efficient practices. In terms of the three identified processes infrastructure refers to the optimisation of mine infrastructure and layouts, time available to work, transport systems and working areas to reduce hazards. Equipment refers to the provision of the requisite tools of trade for all employees and ensuring that they are capacitated to conduct their work safely. This entails that employees receive reliable and ergonomically designed tools, and that automation and technology are leveraged to improve safety outcomes by mitigating human error and physical exertion. Environment conditions entail creating an environment conducive to safe work by ensuring that working conditions are cool, free of environmental hazards such as dust and gas, and that seismic conditions are monitored and appropriately responded to.

The systemic aspect also refers to how information is gathered and processed to address the health of the mine. Systemic interventions aim to facilitate and advance systemic development. These interventions can also maintain systemic health by ensuring that relevant progress is adequately sustained at the operational level. By focusing on systemic health and ensuring that risk response is efficient concerning the risks identified at an operation, a solid foundation for success is established. The success of systemic interventions hinges on the integration of data driven risk management and monitoring systems, which allow organisations to anticipate hazards and implement preventative action. By focusing on leading indicators such as hazard ratings, environmental conditions and equipment or infrastructure alerts, mining operations can shift from a reactive to a proactive approach. This focus also allows for continued improvement in safety performance.

Meanwhile, a crucial aspect of systemic intervention is the human phase, regarded as humanistic interventions. Humanistic interventions refer to those focused on human factors and behaviour. This encompasses leadership and its various concepts, including ownership, culture, employee engagement, and training at the operation. These interventions promote the development of organisational culture. The overall implementation of humanistic interventions enables a working method to be embedded at an operation, fostering engagement and buy-in from all employees. Without focus being placed on attention to the humanistic element, even the most well-designed systemic interventions run the risk of failing to achieve the desired outcomes.

The benefits realised from humanistic interventions should enhance safety and operating performance, leading to sustained improvements in these parameters. Humanistic interventions enable systemic interventions to be sustained at mining operations, eliminating the risk of short-term benefits that fade away over time.

The holistic approach to ensuring that both systemic and humanistic interventions are implemented and monitored simultaneously should guarantee that the benefits of both are realised. Systemic health, coupled with a humanistic approach, should facilitate sustainable improvements within an organisation. Systemic health provides the structure and procedural foundation whilst humanistic interventions complement this with buy-in, compliance and continuous improvement.

The achievement of systemic development is founded within the strategy, structures, policies, procedures and processes of an organisation and individual operations. An overarching strategic imperative of the organisation is followed, but at times individual operations may require enhanced focus to be able to achieve these imperatives. This flexibility allows for context specific issues to be addressed at mining operations. Applying these fundamentals yield key improvements to safety and operational performance. Embedding this integrated approach in strategy, policy and procedure ensures that there is alignment and that interventions are operationalised effectively.

A deeper discussion of various systemic and humanistic interventions alongside the key issues outlining the mining industry will be discussed below.

2.1.12. Shift and face time availability

In order for mining activities to be conducted successfully, mining crews need to be able to spend a certain amount of time on the face (Pelders et al., 2021, p. 429). The current traditional shift times are becoming increasingly constrained due to the increase in travelling time to working places and associated production activities (Pelders et al., 2021, p. 429).

In addition to the constraints due to travelling time, the depth of the operations coupled with the low application of technology can lead to further losses in available shift and face time (Neingo & Tholana, 2016, p. 285).

Changes to shift cycles can enhance productivity and viability in the mining industry (Pelders et al., 2021, p. 433). The adoption of shift cycles can mitigate the negative influence of impaired productivity, worker fatigue and less time spent on the mining face (Pelders et al., 2021, p. 433).

It can then follow that being able to optimise the current shift arrangement to allow for more face time via the optimisation of the vertical and horizontal transport of mining crews can also lead to the realisation of these benefits.

2.1.13. Risk management systems

A risk management system can be described as the collection of an organisation's initiatives, activities and other elements that aim to reduce occupational injuries and losses (Sundström & Nygren, 2023b, p. 326). Various data points exist within operations, providing numerous data to management at a mining operation. How this data is handled is integral to the success of systemic and humanistic interventions. Baghaei Naeini and Badri (2024, p. 1) argue that a coherent and integrated system to manage risk is currently lacking in the mining industry, which is at odds with the data collection that can be provided currently.

With specific reference to mining operations and the influence on safety performance, there are important points to note. The first is that for an effective risk management system to be in place, it is imperative that workplace hazard ratings systems are developed and acted upon (Korban, 2015, p. 371). Areas that are identified or reflected as dangerous typically show an insufficient level of control over the workplace, which can lead to losses occurring in these areas (Korban, 2015, p. 371). In the context of the mining industry, these losses can relate to adverse safety implications for employees or financial losses due to mining panels being impacted by the type of losses that have occurred.

Risk management systems are integral in the provision of leading as opposed to lagging indicators. The focus on leading indicators will allow for the prevention of injuries and allow a shift from a reactive to a proactive approach.

Both the physical conditions of a working place and the identification of human behaviour in work activities can be identified through the application of audit

examinations of working places (Korban, 2015, p. 371). It is critical to understand that the measurement of both physical (being the systemic approach) and human behaviour (humanistic approach) can be measured via risk management systems, as it creates a foundation for measurement and improvement to be seen at the operations when considering the interventions implemented.

The quality of these hazard and risk identifications should be a critical part of the risk management system, as they provide insight into the different safety related challenges that have been identified (Korban, 2015, p. 371).

These different areas serve to highlight the importance and the role of risk management systems in improving safety practices but also how the information generated from these areas can serve to provide insight into areas that will require systemic or humanistic interventions to address. It is a key part of the basis for information that needs to be provided and provides guidance on the type of intervention required to address the root cause of the challenges arising.

This is illustrated by Benson et al. (2024, p. 6) and the intervention process followed in the process industry. This process focuses on hazard identification and risk assessment interventions first, then shifts to behavioural safety interventions, followed by safety culture interventions before a ranking of hierarchical controls.

2.1.14. Technical challenges associated with the mining industry

There are numerous technical challenges associated with the mining industry. Operations need to ensure that these technical aspects are accounted for and well mitigated to ensure that operations remain successful in terms of safety and operating performance. Ignoring these technical aspects can compromise employees and the provision of safe work. These areas include but are not limited to:

Seismicity

The prevalence of seismic events and subsequent rock bursts are still high in the South African gold mining industry, particularly in deep level mines exceeding 2000m (Joughin, 2024, p. vi; Scheepers & Malan, 2022, p. 120). The depth of mining is a contributing factor to increasing stress levels, which leads to the increase in frequency of mining induced events (Sun et al., 2024, p. 2). These incidents have the potential to

have serious adverse safety consequences, particularly when considering the mining of pillars (Mark & Gauna, 2017, p. 108).

There have been significant improvements in the amounts of injuries recorded from these types of events. This is mainly due to systemic improvements made to working places and support designs (Joughin, 2024, p. vi). These interventions include but are not limited to i) the innovation in support systems being done, ii) the adoption of rock bolting and the installation of steel netting, and iii) the provision of LED lighting allowing for easier identification and remediation of hazards (Joughin, 2024, p. vi). These key initiatives also form part the fall of ground action plan within industry.

Whilst the prevalence of seismic events is still high, the potential for injury or loss of working places will remain high. The instances where successful interventions have driven real risk reduction need to be monitored and maintained. The main areas that have contributed to the reduction of seismicity related incidents relate to the understanding of the geological construct of the mine (Netshilaphala, 2019), compliance and optimisation of support standards (Mark & Gauna, 2017, p. 113; Masethe et al., 2025, p. 66; Rogachkov, 2017, p. 42), and effective risk management and seismic monitoring (Sun et al., 2024, p. 1). These various measures help to transform an activity that is inherently unsafe to one that can be conducted safely (Mark & Gauna, 2017, p. 113).

Further improvements need to be identified to drive further risk reduction. Incremental improvements, with each contribution reducing risk and the chance of injury leads to real risk reduction over time (Joughin, 2024, p. vii).

It is clear from the examples provided that to manage the influence of seismicity at mining operations, a multifaceted approach focusing on systemic improvements would not be successful without a focus on humanistic interventions as well. This relates to how well employees are trained and if the impact of the additional work required is discussed with them to ascertain buy-in. This can also include the influence that the additional work would have on remuneration incentives.

Ventilation

Deep level underground mines span vast areas and require complex ventilation systems to ensure the provision of sufficient air to underground working places (Jacobs et al., 2022, p. 204). The main hazards that can be attributed to a ventilation system include i) high temperatures, ii) dust pick up and iii) gas build up (Jacobs et al., 2022, p. 204). These three hazards pose risk to employees and need to be monitored and mitigated.

The prevalence of high temperatures in a mining environment can reduce cognitive ability, and hence lead to increased accidents due to a decreased safe working state of employees (Chai et al., 2025, p. 6).

In the absence of an effective ventilation system, areas will not be able to be mined as employees will not be able to enter working places that meet industry standards. This can relate to production losses. If these warnings are not adhered to, it may result in serious injury to employees exposed to these hazardous conditions.

The provision of a working place that meets and exceeds industry standards also plays a role in the culture of an operation and perception of leadership in a working environment (De Jager, 2019, p. 38). This is due to the exposure of the workforce and conditions that they are expected to work in playing a key role in how these aspects are viewed. It also talks to the exposure and tolerance level for risk at an operation that is either condoned or not (De Jager, 2019, p. 38).

A healthy working place can thus influence employee performance and morale. This can also be extended and to a certain degree amplified in the mining industry, due to the risk profile of mining.

Whilst the provision of ventilation to working places is technical in nature, this aspect links to systemic and humanistic interventions and showcases an example of a focus area where the interplay between the two elements should be considered.

Mining Flexibility

Production flexibility in mining is contingent of the provision of available face length to be mined (De Jager, 2019, p. 253). The less face length available, the less flexibility there is with regards to mining activities.

Not having production flexibility will influence production performance negatively. This is due to a reduction in the available mining areas.

There is usually no short term solution to this challenge, with it being most effectively addressed via development to generate more face length (De Jager, 2019, p. 253).

Limited mining flexibility may lead to increased mining of pillars which may then link to seismic and safety challenges outlined earlier.

Gender Ergonomics

Mining equipment has historically been designed for males to use, with minimal consideration given to how female employees would be able to operate equipment. This consideration is further entrenched through training and induction procedures when utilising equipment underground. The common consensus is that equipment utilisation requires a degree of strength that female employees will not be able to attain due to fragility. The female employees are thus then assigned tasks that require less physical exertion versus male counterparts (Benya, 2017).

2.1.15. Humanistic interventions

As outlined in the key concepts, the role of humanistic interventions is to focus on the improvement of the human factors and behaviour (De Jager, 2019, p. 180). The humanistic interventions facilitate the development of organisational culture, which is a key imperative of making the interventions sustainable. These interventions, as per the operational definition are focused on the improvement of culture, leadership, employee wellness, value orientation and engagement (De Jager, 2019, p. 180). These areas will be explored in the paragraphs to follow.

2.1.16. Safety culture

One key outcome of organisational and systemic development in coherence is the generation of a safety culture.

There is no agreement relating to what the definition of a safety culture is, with varying definitions applied (Bisbey et al., 2021, p. 90). Safety culture can thus refer to how safety is approached and the value placed on working to standard and safely. It is the belief and commitment that work can be done with zero harm and how this is integrated into the operation.

The core of an informed safety culture should be underpinned by four effective sub-components that cater for a i) reporting culture, ii) just culture, iii) flexible culture and iv) a learning culture (Zanko & Dawson, 2012, p. 8). This culture is developed over time and behavioural enactments serve two functions to i) improve safety outcomes directly and ii) reinforce safety culture. These factors are communication and information exchange, teamwork and collaboration, incident reporting and rewards and punishment (Bisbey et al., 2021, pp. 101-102).

Despite the lack of agreement on definition, the influence of a safety culture in mitigating risks and improving safety performance in mining operations is widely accepted as crucial to success.

This is taken a step further by the removal of the notion that accidents are going to occur due to inherent risks that are posed (Hudson, 2001, p. 5); and that the safety maturity of an organisation can potentially be measured (Foster & Hoult, 2013, p. 62). This statement is a key concept as it highlights the influence and ownership that one should have on safety performance and links into what is expected from a humanistic intervention as well.

It has been recorded that one of the largest impacts on safety and that will influence safety outcomes is the concept of safety management commitment (Zhang et al., 2022, p. 14). Safety management commitment entails the leaders' attitudes and dealing with safety related risks (Zhang et al., 2022, p. 14). The way that leadership approaches and deals with safety can have a positive impact in terms of reducing the quantity of accidents incurred in a mining operation (Zhang et al., 2022, p. 14).

Typically it is to be noted that systemic or technical interventions are undertaken before organisational measures (Benson et al., 2024, p. 6; Lööw & Nygren, 2019, p. 444). The approach required in mining to improve safety will require the implementation of both hard (systemic) and soft (humanistic) measures (Lööw & Nygren, 2019, p. 444). Furthermore the improvements related to purely technical interventions are becoming limited and focus needs to be placed on behaviour as well (Hudson, 2001, p. 14; Sundström & Nygren, 2023b, p. 316). The development of a safety culture thus helps to achieve this outcome.

Nearly all recommendations to improve safety performance require the implementation of a safety culture (Sundström & Nygren, 2023b, p. 321). A caveat noted is that the improvement in safety culture can be determined by access to resources and information (Hudson, 2001, p. 12). Furthermore the interdependence of the safety culture and the measurement and recording of risk is paramount (Haas & Yorio, 2021, p. 663). This is due to these areas not being able to act effectively in the absence of one another.

This links to the concept of conducting systemic and humanistic interventions concurrently. This is further reinforced with the recognition that systems cannot progress efficiently without the culture progressing at the same time and the application of this in inverse applies as well (Foster & Hoult, 2013, p. 63).

The impact and integration of a safety culture and safety systems is expanded upon and is integral to addressing the safety challenges in mining operations (Jansen & Brent, 2005, p. 719). The emphasis is placed on the impact of leadership and organisational structure on safety outcomes, with this being done in conjunction with an effective safety management system (Jansen & Brent, 2005, p. 724).

What makes a safety culture successful is the impact of shared beliefs and the interaction of this with an organisation can produce behavioural norms (Reason, 1998, p. 294). The impact of being alert to and obtaining the right kind of data is critical to creating an informed safety culture (Reason, 1998, p. 294). This entails always having respect for the working place and environment that work is conducted in and is imperative to creating safe behaviour.

The development and subsequent maintenance of a safety culture require ongoing vigilance. Compromising on the various aspects outlined above may lead to regression of the safety culture or the absence of one. This compromise can occur as various pressures are experienced. The build-up of these compromises, or “normalisation of deviance” can lead to negative safety outcomes (Sedlar et al., 2023, p. 291).

2.1.17. Behavioural aspects of safety performance

The long-established reasoning around behaviour and safety is that accidents can be caused by unsafe behaviour. The provision of an effective safety system in isolation does not ensure successful safety outcomes (De Jager, 2019, p. 44). Rather, the behaviour of employees needs to be addressed to ensure that systems and processes are turned into reality (De Jager, 2019, p. 44).

As safe behaviour can be established, it is therefore logical to assume that maintaining this behaviour will reinforce it (Anderson, 2005, p. 113). The approach to policy and behaviour can be tough to change if safety is not at the forefront, and relevance of safety understood to drive behaviour change (Sundström & Nygren, 2023b, p. 322).

However, the impact of establishing correct behaviour is focused on front line workers and supervision, and not necessarily extended to management in the same degree, and the role that their behaviour and attitude can play in poor safety performance (Anderson, 2005, p. 115). This can be highlighted with the fact that unsafe decisions made in the boardroom can also lead to the cause of safety incidents occurring in working places (De Jager, 2019, p. 44). The attitude with which work is approached and the importance of working and feeling safe is key to achieving the correct behaviour (Li et al., 2019, p. 2).

Non-reporting of accidents may occur and the reasons behind this can be linked to the safety climate as well as a perception that management does not value safety (Probst & Estrada, 2010, p. 1442). Non-reporting of accidents will have a pronounced impact on the safety performance of an operation and will lead to other interventions not being successful if similar behaviour occurs in terms of not having accountability and open and honest engagements.

Accidents that occur tend to be viewed as the fault of an individual, but this view has progressed to consider that causes can be further from the individual involved. This logical progression has occurred as broader accountability for accidents has been recognised, with a multi-tiered approach followed (De Jager, 2019, p. 208). Production pressures and the way these targets are conveyed may impact behaviour and safety if targets are seen as not being reached and directive pressure is applied (Haas & Yorio, 2021, p. 664). The issue of human behaviour is acknowledged as significant when incidents occur, but the focus on safety preventative measures still extends towards the engineering and equipment aspects of the role (Anderson, 2005, p. 115).

However, a concern noted is that at times when accidents occurred and were reported by individuals, the consequences were not favourable to those reporting them (Probst & Estrada, 2010, p. 1442). In terms of trying to build a safety culture this must be avoided as the root cause of the issues and behaviour must be addressed to ensure success going forward.

The focus and fostering of a culture that focuses on what is addressed in the event of a safety incident needs to be nurtured and distinction made between incidents, the work package and the behaviour displayed (Pillay et al., 2010, p. 137). These key components articulate the building blocks of a just culture, which in turn is a critical component of a strong safety culture (Pillay et al., 2010, p. 137).

The importance of this approach and the creation of an open environment whereby employees can raise safety related concerns without fear of negatively impacting their own careers, employment or disloyalty to colleagues will be only be feasible when focus is placed on the human element in these circumstances (Pillay et al., 2010, p. 137). This is a key area where the dual focus of humanistic and systemic interventions can assist and work in harmony.

Claims can be made that safety is paramount but the number of injuries and accidents tell another story, especially if a culture of under reporting is prevalent (Probst & Estrada, 2010, p. 1443). Steps should be taken to address and correct this culture and ensure honest communication of accidents, especially within the mining industry.

Focus should be placed on leading indicators to improve safety performance. This should also encompass the relationships between management and the workforce.

Engagement and competency should both be addressed (Foster et al., 2008, p. 689). The role of the individual and organisation are both instrumental in addressing behaviour and the establishment of a safety culture and safe behaviour (Tetzlaff et al., 2021, p. 204). The addressing of gaps in commitment and competency is done by ensuring that there is commitment from senior management to address these gaps and the necessary action readily taken (Pillay et al., 2010, p. 137).

To address safe behaviour as outlined above, a broad spectrum of areas needs to be considered. However, by focusing on behaviour only, and not on the provision of the environment, tools, equipment and associated factors of organisation, motivation and reward, a symptom is merely treated, without addressing the root cause (De Jager, 2019, p. 44).

The above factors correspond to the systemic and humanistic approach – which involve the identification of what needs be corrected and then ensuring that it is actioned in the correct manner.

2.2. THEORETICAL REVIEW

The topic of systemic interventions covers a broad spectrum. As such, various theoretical frameworks support and link the study to established theory.

The dominant theory that is utilised for the study is Systems Theory. Systemic interventions in a complex industry such as mining require a theoretical framework that is capable of accounting for the various technical, organisational, human and environmental interdependencies. As such an intervention influencing one of these areas is likely to influence another due to the interdependencies. As the theoretical scope is vast, supporting theories are also employed to further understand how these areas interact and integrate to form a holistic approach and framework. These other identified theories are i) Human relations theory, ii) Social exchange theory, iii) high reliability organisations theory and iv) change management theory. The supporting theories are employed to explain behavioural responses, leadership and engagement dynamics, reliability in high-risk environments such as gold mining, and how systemic interventions are institutionalised. The dominant systems theory provides the overarching structure of how these measures are integrated.

These theoretical frameworks aligned to the study are explored in more detail below:

2.2.1. Systems theory

General systems theory focuses on how changes in one area can influence another due to the interconnectivity of these areas. Changes in a specific area can substantially impact the whole (von Bertalanffy, 1950, p. 5).

Benson et al. (2024, p. 3) elaborated on the relevance of this theory when introducing interventions within a health and safety environment. The application of systems theory principles can ensure that organisations adopt a comprehensive approach to health, safety and the environment, leading to enhanced overall performance.

This holds true in the mining industry, emphasising the complexity of operations and how improvements in key areas, achieved through various means, can generate meaningful change and progress regarding safety and operational performance. This is illustrated by how rock engineering recommendations or an operation's ventilation layout can affect a drilling and blasting schedule. The drilling and blasting schedule rely on other activities that must be carried out, and any delays in these activities can negatively impact this schedule.

This theory's relevance to the study highlights the importance of how changes and improvements in one area can lead to significant improvements in other areas. Safety and productivity are often examined in isolation, but systems theory establishes that enhancements in one area may lead to improvements in other areas. By holistically focusing on both interventions, the benefits should be evident in operational and safety performance.

2.2.2. Human relations theory

The Human Relations Theory, pioneered by Elton Mayo, is also relevant to the study conducted. Human Relations Theory has notable findings regarding human interactions and their effects in the workplace (Bhakuni, 2010, p. 9). Everyone is complex, and various factors influence their behaviour (Bhakuni, 2010, p. 10). Compensation or physical conditions may not be the primary driving factors for employees; rather, the meaning derived from the work conducted and the relational aspects within which work takes place may play a leading role (Bhakuni, 2010, p. 11).

Human relations theory also suggests that employees may become more open and receptive to change the more they are involved in it (Bhakuni, 2010, p. 11).

In the context of the mining industry, the application of this theory is prevalent. This is because employee well-being has the potential to directly influence operational performance. This is illustrated when considering employees' approach to safety and how it can be enhanced through compliance with safety interventions if they feel involved in the process of designing and implementing these interventions. An example is involving crews in the design of a support standard that may lead to improved seismic response. If the mining crews' opinions are considered in the design and implementation, the success of the intervention should be higher than that of an initiative directed solely at the crew. This also aligns with systems theory in that it shows that human elements are integral to overall system performance, and both should be addressed to be effective.

This is critical to the study, as the focus on systemic interventions aims to address systemic issues identified by the working crews. The application of human relations theory explains and strengthens this approach.

2.2.3. Social exchange theory

Social exchange theory provides an additional lens to use alongside other theories. Social exchange theory posits that the exchange of goods between two parties is based on the potential costs and benefits that can be incurred. The costs and benefits of each exchange or transaction are evaluated, with the most profitable options typically being the ones individuals select (Homans, 1958, p. 606).

In the mining industry, operational and safety performance are assessed on a cost-benefit basis. Mining crews often receive financial rewards for meeting safety and operational targets. This results in a cost-reward exchange where greater effort in these parameters leads to a larger financial reward. The benefit of achieving these parameters also reduces the likelihood of adverse outcomes, whether from a disciplinary standpoint or an unfavourable safety incident.

In the context of this study, applying social exchange theory can illuminate why specific interventions are either engaged or disengaged by the workforce. When integrated with

systems theory, it illustrates how behavioural responses either improve or undermine safety systems.

2.2.4. High reliability organisations theory

High-reliability organisations theory posits that high safety standards can be met even in increasingly complex and challenging industries, regardless of the level of inherent risk (Sutcliffe et al., 2017, p. 1). The theory of high reliability is directly linked to a strong organisational culture, the process of actively searching for any non-compliance to policies and procedures with a focus on corrective action, and transparency and openness in achieving this in the organisation (Sutcliffe et al., 2017, p. 2).

The application of this theory is fundamental in the case of systemic interventions. For operations to be safe and successful, the focus is on developing a strong culture as one of the facets of organisational development, along with effective processes to manage any identified hazards. Doing this within a framework of engagement with mining crews and transparency about what the operation needs to achieve is directly in alignment with HRO.

The focus on systemic health and ensuring the correct equipment and infrastructure for mining crews aligns directly with HRO theory. Continuously reviewing hazards and identifying their root causes further supports alignment with HRO theory.

2.2.5. Change management theory

Change management theory prescribes a process that must be followed to ensure that change can be successfully navigated within an organisation. The focus of change management theories is creating a structure to propose change, with logical steps being followed (Saetren & Laumann, 2017, p. 2). These logical steps do vary, but at their core, they involve creating awareness, commonality, a path to implementation, and a means to monitor and improve over time (Saetren & Laumann, 2017, p. 2).

This logical flow should guide the implementation of any interventions in practice; however, the literature suggests this might not necessarily be the case as noted by Phillips and Klein (2023, p. 189).

Although models, theories, and concepts are utilised effectively in academia, change management is implemented through tools and techniques. This may be either done in isolation or as part of an integrated approach (Phillips & Klein, 2023, p. 189). Adding to this complexity within change management is that organisational change is viewed differently by each practitioner, and determining the suitability and appropriateness of which model to use is made difficult (Phillips & Klein, 2023, p. 189).

Understanding these nuances plays a pivotal role in the study and in implementing systemic interventions. The answer to what needs to change, why, and how the change must be effected are critical to the study and the potential answers it will yield. Although each operation will have nuances and a range of approaches that can be followed, ensuring structure in the approach can lead to observations about what is influential in causing or supporting change.

2.3. EMPIRICAL REVIEW

The empirical literature review examines the application of different aspects of systemic and humanistic interventions and encompasses the following:

1) Systemic Interventions in the mining industry inclusive of
    a. The role that productivity and innovation play in the mining industry and how these trends are applicable.
    b. Safety Frameworks.
    c. Shift time available.
    d. Risk management systems.
    e. Technical challenges identified.

These systemic interventions are often supported or enhanced by the application of humanistic interventions. These humanistic focus areas centre on the safety culture and behavioural change necessary for sustained improvements.

2) Humanistic interventions undertaken in the mining industry are inclusive of:
    a. Leadership and the role that this plays in fostering employee engagement.
    b. Ownership of the process undertaken

c. Facets of safety culture within organisations and how this is required for enhanced safety performance.
d. How behavioural aspects are intertwined with safety performance.

Where possible the integration of these aspects will be searched for and considered.

The application of these interventions will be sought within the gold mining industry. If not found, then applicable studies are sought from within the larger mining industry. The application of systemic interventions to improve safety conditions are applicable to the entire industry due to the commonality of the high-risk nature of mining operations. This is highlighted in industry approaches globally to standardise responses, such as ISO standards (Nygren & Sundström, 2025, p. 14). Within South Africa, this approach is also followed in the form of the zero harm targets and the subsequent development of the Khumbul'ekhaya initiative. This initiative is focused on industry outcomes and introducing a standard approach to improve safety outcomes by concentrating on key areas applicable to the entire industry (Minerals Council South Africa, 2023, p. 2).

In addition to the outline above, the focus will be looked at through the lens of under-developed, developing and developed countries. South African studies will also ensure the lens is applied to what is contextual to South Africa and how the different countries' nuances have shaped various approaches and outcomes. It is important to understand these nuances throughout the various regions, with the context and setting that is important to the research outcomes. Similarly, outcomes help to determine what was easily transferrable whilst also highlighting potential gaps or concerns in implementation of interventions. Sundström and Nygren (2023b, p. 330) highlighted this in their findings which showed that the design, definition and culture of society can influence the nation's industries and further to that, the values of people may shape the respective organisational and safety cultures.

The sections that follow will present empirical findings from each of these areas. This includes information contained within peer-reviewed journals, dissertation submissions and industry reports. These allow the researcher to scrutinise the extent and influence of systemic interventions with measurable outcomes from trusted sources.

Starting with global international research conducted, Sundström and Nygren (2023b, pp. 321-329) conducted an international review of the mining safety research field to explore safety measures and the programs in international research. The systematic review of literature yielded insights into what has been applied in the global mining industry. The extensive literature review showed the relevance and importance of the provision of humanistic interventions and how these have been proven to improve safety outcomes or indeed have a negative effect in their absence. Common themes identified from the research conclude that the development of a safety culture is paramount to improving safety outcomes. Building on this is the focus on leadership and behavioural aspects of employees. It is difficult to ensure safety outcomes when the actions of employees are not aligned with safety as a driving principle. Adding to this is the relationship between management and employees. Management needs to build trust with employees and this approach is enhanced by authentic and transformational leadership, thus inspiring hope in the workforce which leads to improved safety outcomes (Sundström & Nygren, 2023b, p. 325). The research concluded with the caveat that safety culture is nuanced with varying perspectives that should be explored, tying into this study which also focuses on the potential role that a safety culture can play, and the steps taken to inform and achieve this.

Neri et al. (2022, p. 1) studied the mutual interdependences between safety and operations in industrial settings. A systematic literature review was conducted across industries and highlighted how safety and operations are often considered individually without taking cognisance of the interdependencies between them. This study highlighted that literature is not mature in this area at this point, but examples were found to show how safety outcomes are derived from operational interventions and operations outcomes are derived from safety interventions.

Synthesizing the international literature on safety interventions highlights the importance of integrating technical and systemic measures with humanistic measures such as leadership and behavioural aspects of employees. Despite this, literature also shows that safety and operations are considered independently and not how they may potentially influence one another via a holistic framework that embeds a safe way of working that may yield improved safety and operating performance. Global research provides key insights into improving safety performance but also indicates a potentially uniform way of working without considering contextual differences between countries

which may either limit or enhance various safety approaches. Safety is nuanced which makes a one-size fits all approach difficult to follow, particularly in ultra-deep level gold mines with characteristics such as challenging environmental conditions, labour force nuances and lower levels of automation.

Next the focus shifts to developed countries, which are typically high-income countries with advanced infrastructure capabilities. When referring to developed countries with a mining footprint, these include the United Kingdom, the United States, Australia, Canada, Sweden, Finland and China.

Baghaei Naeini and Badri (2024, p. 1) conducted a systemic literature review of the identification and categorisation of hazards in the mining industry. The study concluded that risk cannot be managed successfully without the comprehensive investigation of all its aspects, highlighting a coherent and integrated classification of identification and categorisation of hazards as currently lacking within mining. Recommendations included using a system classification based on occupational health standards in mining.

Lööw and Nygren (2019, p. 437) investigated the safety related developments in the Swedish mining industry over the past 30 years. This exploratory study focused on what was done directly or indirectly to improve the safety situation. This yielded what was effective in contributing to the reduction of accident frequency rates and the broad improvement of safety within the industry. This study showed that the initial trend in improving safety was related to technological development, with further improvements made by having a direct focus on organisational aspects of safety. The effectiveness of these measures was not clear but theoretically showed that an improvement was possible, however causality was difficult to prove. The study showed that for safety improvements to be made, focus should be on both “hard” and “soft” measures. The hard measures included the focus on technology and how this could improve safety, highlighting how the use of technology can act as a barrier by removing employees from exposure to risk through reducing energy release involved in activities. Adding to this was the instance of removing employees from risk completely by automating activities. It also noted that whilst this can curb serious injuries, the instances of trivial injuries or low energy incidents such as slip and falls may increase. Technology cannot provide a barrier to these injuries. Thus, the focus on softer measures such as

leadership and safe behaviour were introduced. This was expanded to include the focus on policy and routines. Empirical evidence exists which shows that the benefit on safety performance of soft measures is proven. According to this study, approximately 50% of mining accidents were attributable to organisational factors, with the major ones being lack of awareness, compliance, communication and production prioritised over safety - all illustrating the need for an embedded safety culture.

Nyoni et al. (2019, pp. 57-61) conducted a systematic literature review to examine the relationship between organisational factors and residual risk management in the context of accident causation in mining. It envisaged that the improvement of risk controls can improve the safety outcomes of mining companies. It also links these improvements to the presence of organisational factors such as leadership, safety culture, communication and supervision as organisational factors that shape risk controls and play a role in the efficacy of risk management systems. This study thus highlights the importance of the interplay between systemic and humanistic interventions.

Sedlar et al. (2023, p. 290) in a qualitative systematic review, found that the concept of the normalisation of deviance occurs over time and is gradually accepted by the desensitisation to risk by experienced individuals or groups when recurringly deviating from standard operating procedures. This is generally attributed to risk normalisation, production pressure, culture and a lack of negative consequences. These instances erode the safety culture generated, providing critical insight into what may detract from safety performance.

Zhang et al. (2022, p. 1) outlined the seriousness of leadership in ensuring workplace safety and the role that their behaviour plays in the mining industry. Safety management commitment and safety incentives were found to have increased employee’s safety behaviours, with the influence mediated by safety training, policies, and communication with effective feedback. The influence on these measures is important to the study to understand what may be done to improve safety outcomes.

Sundström and Nygren (2023a, pp. 1010-1019) investigated the safety initiatives that support the development of a safety culture in the Swedish mining industry. As illustrated earlier, a safety culture has been shown to improve safety outcomes, hence

understanding the components that support it is important. The study concluded that safety initiatives focused on improving organisational structure and processes can be connected to safety culture development in both theory and practice. These various safety initiatives are inclusive of i) development of an organisational structure and culture ii) operational safety systems iii) operational safety management programmes iv) the improvement of risk reporting practices and v) development of accident investigation processes. This highlights the role and interplay that systemic and humanistic interventions have and how they drive safety performance together.

Tetzlaff et al. (2021, p. 201) conducted a retrospective analysis of occupational health and safety in mining reports. This study concluded that repeat accidents are likely to occur if cultural drivers are not understood and shared within industry. The nuances to safety culture are thus critical to understand and disseminate. The provision of a systemic intervention in isolation would not have improved safety outcomes, making this an important reference point for the current study.

Murphy et al. (2021, pp. 1864-1872) conducted a case study in Montana on safety climate. The study concluded that strong safety leadership is one of the best approaches to improving safety climate within an organisation. Training plays a critical role in this, with pre and post-test assessments showing significant improvement. This study illustrates how training should be of an ongoing nature.

Ismail et al. (2021, p. 1) conducted a systematic literature review mainly on developed countries. The study focused on the influencing factors on safety culture in the mining industry and concluded that behavioural dimensions are the most significant contributor towards achieving a safety culture, with management commitment being the highest. Since this study considers systemic interventions implemented and driven by senior management, the findings can relate to this critical study.

Chen et al. (2022, p. 1) examined the effect of work values on miners' safety behaviour, the mediating role of psychological empowerment and the moderating role of safety climate. The study concluded that work values positively predicted safety behaviour with empowerment mediating the relationship between work values and safety behaviour. Interestingly, the moderating role of safety climate was not supported.

Yang et al. (2022, p. 15) examined the influencing factors, formation mechanism and pre-control methods of coal miners' unsafe behaviours through a systematic literature review. This study concluded that unsafe behaviour can be controlled via the following aspects i) establish a safe atmosphere, ii) strengthen safety education, iii) strengthen supervision, iv) improve working environment, v) strengthen internal communication and vi) positive incentive measures. Understanding what drives safe and unsafe behaviour is critical to this study, with the recommendations providing a proven means of comparison.

Yin et al. (2023, pp. 5-15) modelled the psychological and behavioural dynamics in the unsafe state of coal miners in China. The study concluded that psychological characteristics had a positive effect on stress and safety psychology. This indicates that psychological characteristics are predictive of potential safety events. This study shows how important the human element to work is, and how important it is to deliver safe work. The state of employees can contribute or detract from safety initiatives and should thus be considered in the application of the systemic interventions.

Matysek and Fisher (2016, pp. 1-2) conducted a study on the Australian iron ore mining industry to determine the improvements that have been made due to the adoption of technology and innovation. The findings from this study showed that there is an up to 15% improvement in productivity from the adoption of automated processes, with other benefits being improved safety, operating cost reduction and environmental benefit. The role of the Australian government in creating a feasible environment for innovation is also noted, with companies being rewarded for these initiatives, which is especially critical when capital is constrained. This finding sets developed countries apart from developing ones as well as, the South African context, and will be revisited in those sections.

Collectively empirical evidence from developed countries illustrates that advanced risk management systems, automation and structured safety leadership models contribute to improved safety outcomes. These emphasise the importance of proactive risk management, data driven decision making and managerial commitment and leadership in driving safe work practices. The literature further reveals that behavioural and leadership interventions are strongly supported by robust systemic controls, which reinforces the argument that humanistic interventions are most effective when

embedded within safety systems. The context from these developed countries is such that operations are exposed to higher levels of automation, stable labour relations in most instances and well-resourced organisations. Literature from developed countries reinforces the value of integrated systemic and humanistic interventions, but the insight is potentially limited in terms of its effectiveness within more labour intensive or resource constrained mining contexts which are more prevalent in developing countries. This is a similar critique to global research.

The second area to be discussed is that of developing countries. These countries are typically middle-income and are transitioning to higher economic development. They are similar in development to South Africa, providing crucial learnings.

Darabor (2023, p. 66) conducted a case study on a gold mine in Ghana to determine the effect that strategic management can have on the achievement of organisational performance. The study found that in the context of this setting, strategic management practices had statistically positive effects on the operational mine's performance. As outlined in the conceptual review, systemic interventions are strategic in nature, and this study frames the positive effect that could be expected from these systemic interventions.

Milošević et al. (2025, p. 1) conducted a study to identify the critical factors that affect occupational health and safety in a changing mining environment. The study examined how work equipment and environmental factors, human behavioural factors relating to health and safety and organisational climate influence safety satisfaction and how this affects overall performance. Organisational climate factors and safety satisfaction were found to improve safety performance. This also aligns with research in developed countries, suggesting a common thread into developing countries.

Banson (2020, p. 19) conducted a study on the effect of mechanisation on the safety and productivity of a gold mine in Ghana. The findings concluded that in this setting, gold production increased by 94%, reduced manpower by 53%, improved efficiencies and reduced the injury frequency rate and accidents by 1,160% and 94% respectively. The caveat to this is that it proved expensive, had the potential to induce labour unrest and to increase fatal mine accidents due to the nature of the machinery. These nuances are important to understand when relating to the South African mining

industry, with cost and potential labour reduction being a barrier to the implementation of mechanised operations.

Muah et al. (2021, p. 41) conducted a study on the Ghanaian mining industry that explained how safety management practices and safety programmes influenced job safety and employee commitment. The study found that job safety had a strong positive association with employee commitment and demonstrated that safety in the workplace leads to higher employee commitment levels in achieving organisational goals. Further it advised industry to adopt industry wide safety practices to ensure that employees develop a sense of attachment required for organisational growth. This demonstrates that a focus on safety related outcomes can also assist to improve productivity and aligns with the industry initiatives outlined in South Africa.

Dodoo et al. (2023, p. 1) examined the influence of learning-orientated leadership for promoting future directed workplace safety in the mining industry. This study was done using a sample of 316 employees in the Ghanaian mining industry, and it showed significant positive associations between safety learning, employee safety voice and safety stewardship behaviours. The implication of this study is that for safety outcomes to be improved, management needs to recognise the need for safety learning behaviour at a supervisory level. As outlined in the conceptual review, these are key components of a safety culture as well. Noting the strong associations observed in this study, these key indicators can provide value if observed in the context of the current study.

Opoku et al. (2020, p. 23) conducted a study on how organisational safety culture could be applied to reduce employee accidents in the Ghanaian mining industry, and it concluded that safety culture is a positive predictor of work safety, management safety practices, safety programmes, co-worker safety and supervisor safety. The study further concluded that safety performance can be improved by ensuring that a safety culture is instituted within mining operations. The presence of improved safety outcomes and influence on culture of systemic interventions is thus important to understand. The interventions should be seen to influence and embed a safety culture to ensure success.

Widyanty and Kasmo (2019, p. 287) examined the linkages between safety culture and employee performance in an Indonesian gold mine. The findings were that an improved safety culture has an impact on job satisfaction and motivation, which in turn leads to improved performance. It is therefore beneficial to cultivate a safety culture to improve employee performance. This is a productivity lever that can be related to the South African context where technological improvements are not readily available to improve productivity.

Kainat and Shahzadi (2021, p. 21), when examining how safety and health were managed in the mining industry in Pakistan, concluded that exposure to risk can be controlled through compliance to appropriate standards. This should be done through the establishment of a risk management and review programme. It further aligned with findings from the Swedish mining industry by concurring that the approach to safety in mining needs to incorporate both “hard” and “soft” elements. This further confirms the benefit of a holistic safety approach.

Cotrina-Teatino et al. (2025, p. 2) examined how accidents in the mining industry could be reduced by the implementation of a daily safe talk program based on reports of substandard acts and conditions in Peru. This was a quantitative correlational design study which focused on addressing critical risks such as ground support failures and defective tools, with the post implementation period of the daily safety talks resulting in a reduction of 73% in substandard acts and conditions, with incidents decreasing by 60%, affirming that safety talks are effective in improving safety conditions and reducing incidents in the mining industry. Taking this further in relation to the research, this also shows that if an effective risk identification system is in place with effective feedback mechanisms, safe outcomes will be achieved, which also corresponds to the presence of hard and soft measures.

Joe-Asare et al. (2023, p. 1) examined the causal and contributing factors of accidents in the Ghanaian mining industry, focused on accidents of all severity levels. The study concluded that leadership flaws were associated with the most severe outcomes whilst the physical environment related to accidents with the least severe outcomes. Most accidents were attributed to procedural non-compliance, inadequate supervision and unsafe design/construction. This study emphasises the importance of humanistic

measures to enhance and ensure compliance with safety frameworks and how this can lead to improvement of safety outcomes.

Synthesising empirical evidence from developing countries illustrate that even with constrained resources, integrating systemic and humanistic measures will improve safety outcomes. The cost of these interventions, labour intensity of operations and potential technological limitations are important considerations. This shows that interventions should be targeted to get the most value out of them. It also highlights that interventions do not have to rely on expensive technologies but that simplistic measures that incur minimal cost, such as daily talks can significantly improve outcomes. This also illustrates the value of humanistic measures to complement the systemic identification, communication and engagement on identified risks within a mining organisation. Leadership and the development of a safety culture again remain integral to embedding sustainable safety practices and not losing the value of systemic interventions. This supports the findings in developed countries but also illustrates the potential difficulty in transferring them to developing country contexts. This suggests that integrated approaches are universally beneficial but must be adapted to contextual realities that the operational mine is exposed to.

The following discussion area is the South African context. This is the key focus and setting of the current study. Whilst South Africa is also classified as a developing country, it operates with its own unique characteristics and challenges.

Neingo and Tholana (2016, pp. 288-290) analysed the production trends in gold mining in South-Africa. This study showed that the overall productivity in the industry is decreasing due to reduced labour productivity. Within South-Africa, gold mines are classified as having an over-reliance on labour, with a lower adoption of technology. This has led to more expensive mining activities and unit cost of production. Innovative ways are required to improve this performance. The operating constraints in South Africa are different from those of developed countries, particularly with regards to the approach to innovation and technology adoption. One way of achieving this could be through the improvement of safety parameters. If zero harm can be achieved, the downstream effect will be improved productivity. As the production profile is still highly labour intensive, efforts to improve this are critical. This aligns with the context of the

mining industry set under the conceptual review and clearly highlights the operating constraints within which the case study operates.

The gold mining industry in South Africa has a history of volatility. Schultz and Kusel (2018, p. 81) explored manager-employee relationships during turbulent times at a gold mine through a qualitative study. The study illustrated important themes that can help to improve relationships when volatility is induced. These are i) employee empowerment, ii) trust building, iii) employee voice and iv) development of skills. These are all related to soft skills which shows that the consideration of these when introducing systemic interventions needs to be considered. This is especially true when interventions need to be introduced due to safety related concerns.

Prinsloo and Hofmeyr (2022, p. 1) examined organisational culture, frontline supervisory engagement and accountability as drivers of safety behaviour. The study concluded that the tendency of a supervisor to hold himself and his team accountable is positively correlated with good safety behaviour and is the strongest predictor of safety behaviour when considering the safety climate, supervisory engagement and supervisory accountability.

Masemula (2021, p. 62) examined the impact of safety leading indicators on workplace safety conditions and how this influenced workplace safety outcomes in the context of an operational mine. The study found that there is statistically no significant relationship between safety leading indicators and workplace safety conditions. There is however a significant statistical relationship between safety indicators and workplace safety outcomes. The study advises that employers should place superior focus on compliance of leading indicators to reduce workplace incidents. However, it also does acknowledge that to improve workplace safety, a holistic approach needs to be followed, inclusive of personal and job factors, and unsafe acts conducted by employees. This supports the notion that a multi-faceted approach is required to improve overall safety outcomes.

Nelwamondo (2024, p. ii) examined the impact of Ubuntu leadership on employee engagement within South-Africa's mining industry and examined how values such as respect, empathy, inclusivity, survival and inter-connectedness can address industry specific challenges, which included high accident rates and difficult working conditions.

The study showed positive correlations between Ubuntu leadership and enhanced employee engagement. This suggested a supportive, motivated workforce. A safety culture was identified as a key moderating factor, strengthening the link between these variables. This research highlights the key role of the inclusion of soft or humanistic measures into safety approaches, and the key nuances that are applicable to leadership within South Africa that may leverage improved safety outcomes.

De Jager (2019, pp. 41-59) proposed a systems-based approach to improve safety in the South African gold and platinum sectors. The approach showcased the emerging themes that resulted in improved safety performance. This included a multi-tiered approach to reduce accidents and improve safety in the mining industry. An important driver of safety performance is the societal expectation that mining must be conducted safely. This must be institutionalised and an enabling environment created to enable zero harm. Activities should be systemised and transfer knowledge between employees with the behaviour of individuals established to operationalise safety management systems. This system should then be further “humanised” to ensure culture and behavioural elements, training and employee participation. This ties into the framework adopted by industry. It also encompasses that to achieve safety outcomes, there should be a dual focus on the systems element which is the systems, processes and procedures as well as how culture and softer elements are developed to sustain improvements. This ties into the study to identify if these factors are present in safety initiatives and which are the most beneficial in the operational setting.

Synthesising empirical evidence from South Africa exposes similar constraints to developing countries in terms of resource allocation and technological constraints which may hinder safety interventions. The literature however suggests that systemic interventions such as risk management systems should be complemented with humanistic measures that consider local contexts such as labour relations and cultural nuances. The approach in utilising local culture and leadership approaches may act as a bridge to improve prior volatile labour relations experienced in prior studies. This is reflected in how a measure such as the application of Ubuntu can enhance safety approaches. Evidence also suggests the importance of a holistic and multi-tiered safety approach but also in the importance of operationalising and institutionalising the approach. This is facilitated and sustained through humanistic measures such as

culture development. This is like developing countries in that local contexts need to be considered.

The final discussion area is focused on under-developed countries. This area is also of particular importance as there are nuances to how mining activities are conducted therein. The key differentiating factor can be in the approach that multi-national companies bring and the resource base that they can deploy to enhance mining operations and safety systems. For the purposes of this literature review, the bulk of these areas can be identified on the African continent as well as Papua New Guinea, which is largely under-developed but rich in resources that multi-national companies are trying to obtain access to.

Nguembi et al. (2025, p. 57) conducted a case study in Gabon which explored a systematic risk assessment and safety management approach in the mining sector. The study also integrated a cross-cultural perspective which examined how cultural dimensions may also influence safety behaviour and compliance. The findings illustrated that improved safety outcomes are observed when culturally adaptive strategies are employed. In a multi-diverse context setting such as South-Africa, these lessons from other areas are important to consider.

Mhina (2023, p. 67) examined workplace health and safety practices in relation to employee work performance in Tanzania, with a gold mine utilised as a case study. The study concluded that a working environment where health and safety practices are absent will lead to poor productivity by employees. Therefore, to be productive, a health and safety strategy, which is at the forefront of activities, should be in place. It is recommended to cultivate a precautionary culture which can also be linked to a safety culture in more developed countries.

Yaro and Sali (2023, p. 33) conducted a case study on how effective communication enhanced occupational health, safety and risk management on a gold mine in Papua New Guinea. The study focused on how the effective use of communication could ensure clear dissemination of safety information and standards, assist in fostering a positive safety culture and lead to the reduction of workplace incidents and accidents. The findings concluded that communication is the cornerstone of safety culture and fosters a healthier and safer work environment. Communication gaps can however

occur, illustrating the need for accessibility, simplicity and relevance in the related training programmes. This is a critical lesson as it implies that to be effective, the simplicity and clarity of communication is imperative.

Nguembi et al. (2023, p. 1) examined the safety and risk management of Chinese enterprises in the Gabon mining industry. This study concluded that to ensure a safe operating environment, there needs to be an assessment of current operating activities on an ongoing basis. This needs to be evaluated for risk, and then action taken to either prevent, eliminate or reduce the risk. This therefore ensures that a risk and safety management system should be in place at each operation and utilised correctly to ensure that the benefits from the system are derived. Mirroring findings from developed countries by Baghaei Naeini and Badri (2024, p. 1), this study also highlights that not all risks and hazards have been considered and evaluated using a systemic or methodical approach.

Hai et al. (2020, p. 300) examined how to increase productivity and safety to ensure sustainability of the mining industry in Vietnam. The improvement of monitoring methods and combatting of natural hazards was identified as one of the key factors to improve productivity and safety performance. This highlights the need to ensure that efficient safety monitoring is in place and the benefit that is likely to be missed out on if there is a deficiency in the current systems needs to be laid out.

Collective research from under-developed countries illustrates that systemic and humanistic measures are dependent on cultural adaptation, communication and leadership to overcome resource constraints. Learnings from this context reinforce the importance of context specific safety frameworks and targeted interventions that will yield the most cost-effective improvements to safety performance. This is important to the South-African context which is also more resource constrained than that of developed countries.

Across all contexts of global, developed, developing, South African and under-developed contexts, consistent patterns emerge. The first is that integrated interventions that combine systemic and humanistic measures improve safety outcomes. The second is that contextual nuances are important to the applicability of the type of intervention that should be implemented. Thirdly, humanistic measures

such as leadership, engagement and culture are critical to sustaining improvements in safety performance that are derived from systemic interventions. Systemic interventions such as risk management systems provide the framework that supports humanistic interventions.

2.4. LIMITATIONS AND GAPS IDENTIFIED

Focusing on a gold mine as a case study is rarely explored in the literature, offering a unique learning opportunity. The pre- and post-implementation windows, along with senior management's perceptions of how systemic interventions influence safety and operating performance, can enrich the existing body of research. The recorded operating and safety performance, combined with the views of senior management, provide a holistic perspective on the impact of these interventions, which is absent in other studies.

There is a vast amount of literature on systemic interventions in the mining industry and across other sectors. However, this literature's scope is limited when considering the perceptions related to implementing both types of interventions, identifying these interventions, and their effects on enhancing safety and operational performance.

Further to this when studies are conducted, there is usually a focus on a singular variable, and not on the holistic approach used to effect change at an operational level.

Gaps and recommendations for future research identified in the literature are outlined below:

- Notable literature exists about complex (systemic) and soft (humanistic) measures that have been introduced to facilitate safety improvements (Lööw & Nygren, 2019, p. 444). However, this study was conducted in the Swedish mining industry, presenting a research gap in the South African context. The research gap is to investigate a holistic approach (Lööw & Nygren, 2019, p. 444).
- The identification of factors such as supervision, leadership, safety culture and communication provides direction of focus towards organisational factors that could be investigated to determine their magnitude of influence, whilst also focusing on prioritising them in mining operations. These usually overlap with

shaping the design, implementation and maintenance of risk controls in an organisation (Nyoni et al., 2019, p. 61). The nature and extent of the influence of organisational factors on residual risk management should thus be examined, with particular focus on the influence of organisational factors on the functioning and effectiveness of risk controls (Nyoni et al., 2019, p. 53).

- How systemic interventions are implemented to improve safety compliance should be explored, as the literature around this is minimal (Muthelo et al., 2022).
- Safety is a nuanced subject and can be explored in more depth, specifically relating to safety culture, by examining different perspectives (Sundström & Nygren, 2023b, p. 23).
- Further case studies regarding manager-employee relationships in gold operations navigating turbulent times are recommended (Schultz & Kusel, 2018, p. 86). Although this study does not aim to replicate the referenced study in a different mine, the perspectives on humanistic interventions may help address this gap. Humanistic interventions, as outlined, encompass the themes discussed in the study, including trust-building and employee engagement.
- There is a focus from academia on identifying interdependencies between safety and operations , but a more integrated approach towards the identification and evaluation of outcomes, is lacking, particularly from a managerial perspective (Neri et al., 2022, p. 16).
- In understanding the role of leadership in safety management and the effect it has on safety performance, it is recommended that other techniques, such as interviews, be used (Zhang et al., 2022, p. 15). The findings from this study indicate that management commitment to safety and policy can play a role in improving safety performance (Zhang et al., 2022, p. 15). The influence of systemic measures on safety performance can help to understand this role, as evidenced by the qualitative measures employed in the case study.

2.5. CONCEPTUAL MODEL

The conceptual model proposes that systemic and humanistic interventions interact synergistically to influence safety performance. Organisational culture and in particular safety culture, acts as a mediating mechanism through which the effects of systemic

and humanistic interventions can be exerted. The model further recognises that contextual factors inherent to gold mining such as depth, seismicity, environmental conditions and labour intensity may moderate these relationships. This is depicted in the below diagram.

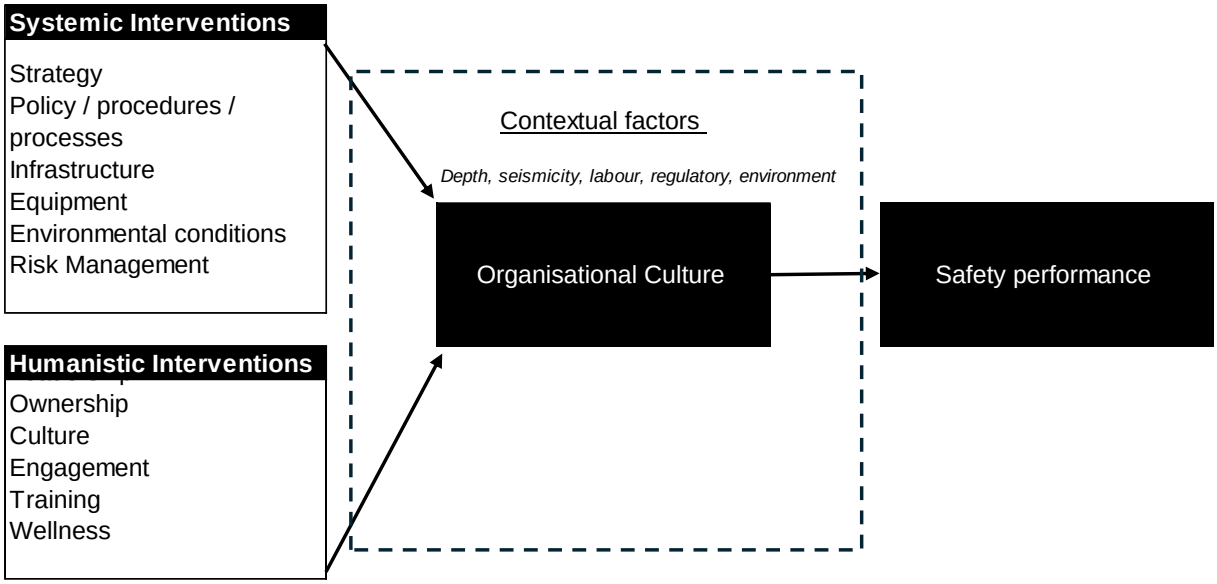

Figure 2-5 - Conceptual model

2.6. CHAPTER SUMMARY

Improving safety performance in gold mining operations has been an important topic for a lengthy period. Various interventions have been undertaken to improve safety results and have been met with varying results. This has ranged from widespread successful industry interventions to shaft or singular operational improvements that have been realised.

It is important to understand these various nuances and what has led to interventions being successful, particularly when the industry needs improved safety performance. The complexity involved in mining operations make it a challenge to design and implement sustainable solutions. Such complexity extends itself to the range of interventions that can be applied, from technical aspects to behavioural focus or culture transformation.

Understanding what has been successful, where it has been successful and how this can be transferred and implemented amongst mining operations is one of the key levers of improving safety outcomes in the industry.

The framework adopted and how this was derived provides an important understanding of the thought process behind risk identification and mitigation, as well as the general approach to safety at mining operations. This in turn provides lessons on how the numerous challenges in the mining industry can be resolved.

The foundational knowledge in place provides a solid base to understand key initiatives and interventions to be reviewed in the context of current mining operations that have experienced challenges, and how this can be measured against what has been done in accordance with proven theoretical knowledge and what gaps or improvements are occurring in practice.

Chapter three will outline the methodological approach used to explore these issues in the context of a Gauteng gold mine.

CHAPTER 3 METHODOLOGY

3.1. INTRODUCTION

This chapter discusses the research methodology, encompassing aspects such as the research paradigm and design, research settings, sampling techniques, measurement instruments, data collection methods, data analysis procedures, ethical considerations, and limitations inherent to the study. This chapter aims to explain the systematic process used in conducting the research, as well as justifying the methodological selections made.

3.2. RESEARCH PARADIGM

The interpretive paradigm, which originated in anthropology, served as the foundation for this research. A fundamental principle of interpretivism is the absence of absolute truth. The opposing perspective asserts that an individual's cultural background and life experiences shape their understanding of truth and knowledge. Additionally, this paradigm is based on the subjective nature of reality and emphasises the importance of perceiving others' perspectives in shaping one's sense of reality (Bryman et al., 2021, p. 34; Rehman & Alharthi, 2016, p. 55). An individual's knowledge is constructed through personal experiences and their interpretation of these occurrences. The perspectives and ideas of researchers inevitably influence their work, affecting the outcomes (Saunders et al., 2018, p. 1904).

Interpretivism encompasses various schools of thought, including constructivist, critical, and deconstructionist perspectives, rather than a singular overarching ideology. A multitude of researchers favour the interpretive approach. Interpretivists adhere to a relativist ontology, asserting that several interpretations of reality exist. The interpretivist paradigm posits that reality is not quantifiable. Interpretivists contend that the complexity of a thing is most effectively comprehended by examining it within its natural context. Grounded theory or another methodology may have been employed; however, the data cannot be utilised to formulate overarching conclusions. The primary advantage of the interpretive technique is the comprehensive examination of a phenomenon within its social context, allowing researchers to interpret their sensory perceptions of sight, sound, and comprehension (Goldkuhl, 2012).

3.3. RESEARCH APPROACH AND DESIGN

This investigation employed a qualitative research strategy. Bryman et al. (2021, p. 48) assert that a qualitative approach seeks to comprehend the influence of attitudes, motivations, and opinions on research by articulating findings verbally. Acknowledging that individuals' views of their social environment are fluid, along with emphasising this reality, substantiates this claim (Bryman et al., 2021, p. 58). The qualitative method was optimal for this study topic because it depends on participants' subjective experiences.

The inductive approach was selected for the inquiry. Theory could be developed by investigation utilising an inductive method (Bryman et al., 2021, p. 24). Prior to commencing data collection, the methodology advised engaging in a preliminary literature review on the subject (Bryman et al., 2021, p. 24). A literature study examines the data and offers an elucidation (Bryman et al., 2021, p. 24). Induction comprehended intricate and often subtle links (Tracy et al., 2006, p. 174). This was essential for addressing the study question since it pertained to the influence and experience of human behaviour on systemic interventions.

The selected research design was a singular embedded case study. Bryman et al. (2021, p. 111) state that research employing a case study design involves a comprehensive analysis of one or more instances. This research methodology is very context- and issue-specific, emphasising the inherent complexity of the latter (Stake, 1995, p. 3). This facilitated the examination of intricate subjects, aligned with the research issue that required resolution. A case study at a single location was selected to better understand the therapies' potential effects in an operational context (Miles et al., 2020, p. 28; Milkman, 2023, p. 12).

Case study designs align with the qualitative approach and are often regarded as a more acceptable research method, as noted by Bryman et al. (2021, p. 111) and Eisenhardt and Graebner (2007). The inquiry into "how" and "why" to thoroughly investigate phenomena distinguishes case study research from other methodologies (Yin, 2018, p. 30). Yin (2018, p. 15) asserts that case study research frequently employs a variety of data sources. Case studies are effective for examining perspectives and offering insights into the conception, implementation, and alteration

of systemic interventions through semi-structured interviews and document analysis (Bryman et al., 2021, p. 111).

The qualitative, inductive, case study design was justified by the study's intention to explore how systemic interventions are perceived, designed, implemented and adapted in a real-life setting. These methods allowed the requisite depth and context to be captured, which would not have been possible with quantitative methods. The chosen design enabled in depth understanding of organisational process and systemic interventions which are consistent with the interpretivist assumption that reality is socially constructed and best understood through participant reactions.

3.4. POPULATION AND SAMPLING PROCEDURE

The case study focused on a gold mine currently operating in Gauteng. As of 30 June 2023, Gauteng had 10 operational gold mines and one in development (PriceWaterhouseCoopers, 2023, p. 5). All these mines offered the potential for exploration to understand the impact of systemic actions.

Systemic interventions could be applied in each operation and might have affected them differently. This is due to the unique dynamics of each operational shaft, which require thorough analysis, necessitating the evaluation of the entire group of gold mines as a population. The fundamental components of a case study are the definition and subsequent delineation of the case (Yin, 2018, p. 16). A case often has a specific temporal and spatial framework (Miles et al., 2020). This was [Mine A] in Gauteng during the 2024 financial year (FY24). The scope was limited to the impact of systemic measures implemented throughout this single operation.

The decision to focus on a single case was justified by the studies aim to gain an in-depth understanding rather than broad generalisation. A single case study allowed for rich, detailed and contextualised insights into systemic interventions and aligns with qualitative research, which prioritises analytical depth.

The population of gold mines was reduced to a suitable and representative sample. Non-probability sampling was employed, specifically focusing on purposive sampling. Purposive sampling involves the intentional selection of a sample rather than relying on randomisation (Bryman et al., 2021, p. 224). This study primarily employed a

standard case study, utilising three fundamental methods of sampling (Patton, 1990, p. 46). A typical case study refers to the selection of a case that illustrates a specific concept or relationship of interest (Patton, 1990, p. 46). Therefore, a sample size of one case was sufficient. This represented a singular situation in which systemic actions have been executed (Miles et al., 2020, p. 28). The single purposively selected case is justified as it enabled detailed exploration of systemic interventions in their natural context which is consistent with qualitative principles.

Purposive sampling was used to select the case. The sample was restricted to i) gold mines in Gauteng, ii) gold mines where the design, implementation, and adaptation of systemic interventions was established, iii) gold mines where these interventions can enhance operational and safety efficiencies, iv) gold mines in stable operational states, and v) gold mines with historical issues pertaining to safety or production performance. [Mine A] was chosen as the case study using purposive sampling. The mine has recently instituted systematic measures to enhance safety performance. The operational and safety performance from previous years is crucial to the study's context. The operation's earlier performance necessitated the required interventions. The accessibility of the operation is also considered. Additional inclusion and exclusion criteria evaluated include i) the operational lifespan of mine, ii) the magnitude of production operations, and iii) various gold mining enterprises. The case encompassed FY24 and FY25, with FY23 as a comparative baseline.

The purposive sampling technique was employed to collect data for the case study, consistent with qualitative research (Creswell & Creswell, 2019, p. 301). This approach aligned with the case's requirements and the established operation where the interventions have been executed. The complete population of the operation included all personnel and all reports regarding the safety performance of the operation, whether internal or external. Purposive sampling was used as the sampling approach for the semi-structured interviews. Senior management was selected for the sample and limited to senior managers involved in i) design, ii) implementation, iii) adaptation of systemic initiatives, and iv) those accountable for delivering these interventions. These criteria were established to ensure that the selected group was intrinsically involved in the development and outcomes of the systemic interventions, providing a knowledgeable and holistic view of the systemic interventions. As such these individuals are best placed to provide the in-depth perspectives required for the

research. A senior manager is typically characterised by an appointment at the E-band Patterson grading level, which often necessitates a decade of operational and managerial experience. The choice of the senior management group enabled the researcher to effectively comprehend the study context (Creswell & Creswell, 2019, p. 301). Senior managers provided the necessary depth and detail to the study through their perspectives. Selected senior managers would also have found it easier to recommend additional senior managers for consideration in the study if data saturation had not been achieved (Pettigrew & McNulty, 1995). Due to the nature of the research, no set number of participants was defined. It was recommended to select participants from the senior management cadre involved in mining operations within the population group as an initial approach. The aim was to collect data until data saturation was achieved. Data saturation, a concept derived from grounded theory, occurs when data collection ceases because new data no longer yields additional insights, indicating that sufficient sampling has been achieved (Charmaz, 2006). Once saturation was attained, the +1 interview yielded no further insights. Due to the qualitative nature of the study, modifications could have been implemented as necessary to enhance understanding. Lastly, participants were proficient in English, as the interviews were conducted in that language.

3.5. RECRUITMENT STRATEGY

To facilitate participant recruitment for this study, the researcher employed a face-to-face presentation of the case study to executive management, and utilised an independent individual, after securing access and approval to perform the case study. Approval and consensus to endorse the study was pursued during an executive management meeting. The study was presented through a PowerPoint presentation and a question-and-answer session. The scope, setting, context, and pertinent material were delineated and approved by executive management, establishing the foundation of the study and defining the parameters, with a member of executive management serving as the gatekeeper.

Upon executive management's approval of the study, the regional general manager and general manager were notified, and their consent was secured. Senior management thereafter authorised access to the persons participating in the study. A session was conducted with the relevant senior management members who possess

familiarity and expertise regarding the establishment's operations, during which the study was elucidated and recommended before scheduling interviews.

Concerning document access, the requisite papers for the case study were presented to executive management (further elaborated in the data collection section), and approval requested for their utilisation. The internal documents used are maintained at the operation using operational document storage protocols. The researcher obtained the documents from the operation, following permission and access to the operation being granted. Only aggregated findings were shared with the organisation, with raw data remaining confidential. Published documents were accessible on the organisation's website. Any additional papers uncovered during the case study were submitted to executive management for authorisation to utilise. The conditions outlined pertaining to aggregated findings also remained in place for these identified documents, with raw data remaining confidential.

The subsequent roles and personnel were employed for the study:

Gatekeeper - an individual who authorised access to and permitted the use or dissemination of information. In this study, an executive management member of the organisation was regarded as the gatekeeper.

Mediator - This individual addressed and resolved conflicts or potential concerns related to the study. The operation's general manager assumed this responsibility and any possible concerns necessitating further guidance were escalated to the regional general manager as needed.

An independent individual - this individual was an industrial psychologist who provided support to the operation without being employed by the company. This person was engaged as a consultant in a consulting firm that employed them and partners with the broader mining company to provide support services related to business improvement, with a specific focus on culture transformation. Additionally, there was no direct contractual relationship with the selected mine. This arrangement ensured that the selected individual and services provided were independent, preventing any undue influence on or by this individual. The role fulfilled by this individual was also independent of operational outcomes and was selected for their expertise in mining operations and proficiency as an industrial psychologist. The independent individual

secured the informed consent of the participants. To prevent an imbalance of power, impartial individuals conducted interviews. This person provided consent through a signed document indicating their readiness and availability to conduct the interviews.

3.6. INFORMED CONSENT PROCESS

The informed consent procedure was an essential component of the study process. The researcher ensured that the target sample and case study participants were thoroughly informed about the study's scope, goals, and direction and how their comments would be managed (Bryman et al., 2021, p. 165). The procedure for obtaining informed consent is detailed below.

Participants were thoroughly apprised of the research (Bryman et al., 2021, p. 165). The study's problem, goal, and context were explicitly described and communicated to the participants (Corti et al., 2000, p. 3). A document outlining the study's scope, context, and purpose was created and shared with participants. This allowed individuals to make an informed choice regarding participation (Corti et al., 2000, p. 3). Participants were not asked to decide on participation immediately; they were given time to process the information presented. Participation was optional and could be terminated at any time (Corti et al., 2000, p. 3).

Following the Protection of Personal Information Act (POPIA), participants submitted an informed consent form before the commencement of the interview process. The informed consent form furnished adequate information regarding the purpose of the study, thereby enabling individuals to make a well-informed decision concerning their participation. This consent form explicitly indicated that participation in the study was entirely voluntary and that participants retained the right to withdraw from the study at any time. The researcher could be reached at 20358725@mynwu.ac.za at any time to report any participant withdrawal. Data collected regarding this individual was to be destroyed within 48 hours.

Consent was obtained to ensure comprehension of these principles, and an impartial individual verified that participants have not been subjected to undue pressure to grant consent. The research proposal and all data collection were conducted in English. Individuals who had trouble communicating, comprehending, or expressing themselves in English were automatically eliminated from the study due to their inability

to understand the presented material. All senior management members in this study were confirmed to be proficient in English. No covert observation of individuals occurred; this principle was articulated, consented to, and formally acknowledged. Participants consented to recording their feedback under anonymity, acknowledging that their responses may be utilised and potentially published in the study.

These principles were outlined in the documents and discussions with the participants. Participants provided a physical signature on the enclosed informed consent document. This verified that the study had been clearly explained to them and that they provided their consent accordingly. The informed consent document received approval from the University Ethics Committee before its use. The ethics numbers granted for this research was NWU-00707-25-A4. The researcher was responsible for accurately presenting and communicating the study to participants. The impartial individual confirmed that no undue pressure or misinformation was hidden from participants and secured their signatures during the informed consent process. Participants completed this sign-off in the presence of a witness. The researcher was prohibited from using any information for which specific authorisation had not been granted.

The company received regular feedback on the study, ensuring that the organisation monitored its progress. The corporation could intervene or request further information if the study did not align with the initial agreement made during the approval process. The feedback provided only included aggregated findings, and not raw data. A summary of findings was made available upon request post-study.

3.7. DATA COLLECTION METHODS

The proposed data gathering methods fulfilled the objectives and targets of the case study. A case study requires analysing multiple data sources (Yin, 2018, p. 114). The data collection methods prioritised semi-structured interviews and document analysis, as specified in the case study objectives, which are recognised as appropriate and credible collection techniques (Yin, 2018, p. 114). Semi-structured interviews served as the primary data gathering method, while document analysis functioned as a secondary data collection method. The use of these two strategies facilitated data triangulation (Yin, 2018, p. 114).

Semi-structured interviews investigated senior management's perceptions of systemic actions affecting the safety performance of gold mines in Gauteng. The semi-structured interviews encompassed various situations and were executed using an interview schedule (Bryman et al., 2021, p. 270). This methodology prioritised the interviewee's perception and understanding of events, along with their assessment of what is significant in interpreting or representing those events (Bryman et al., 2021, p. 270). This aligned with the case study's purpose of investigating senior management's perspectives regarding the impact of systemic actions on safety performance. The emphasis provided by a semi-structured interview ensures this is considered during the interview process (Bryman et al., 2021, p. 270). The selection of the semi-structured interview is justified through allowing the relevant depth and context to be articulated by participants.

The selected interviewees were contacted to schedule the interviews. The request was submitted via an emailed meeting invitation following the briefing session conducted with them to elucidate the study's goal (Bryman et al., 2021, p. 271). This request included the study's approval and purpose. Interviews occurred in person at a mutually determined neutral location with the gatekeeper, where disturbances were minimised (Creswell & Creswell, 2019, p. 302). If a face-to-face meeting was not possible, the interview was conducted via Zoom or Microsoft Teams.

According to Kvale (1994), successful interview conduct necessitated fulfilling the following criteria: i) the interviewer must possess knowledge of the topics to be addressed, ii) the interview must be structured, iii) the interviewer must exhibit clarity, gentleness, sensitivity, and openness, and iv) the interviewer must engage with comments made and provide interpretative responses. The independent person conducted the interviews after satisfying these conditions, particularly concerning understanding of systemic treatments, and was selected to mitigate any issues regarding power or authority requiring examination. This impartial individual was trained to perform interviews and received comprehensive briefings beforehand.

An interview schedule was supplied, and interview methodology was adhered to (Creswell & Creswell, 2019, p. 305; Yin, 2018, p. 126). Essential definitions were provided during the interview to ensure comprehensive understanding of the subjects addressed. Before the interview commenced, the study was summarised, and

informed consent obtained. Probing and follow-up inquiries were posed based on the responses obtained from the interviews (Creswell & Creswell, 2019, p. 302; Kvale, 1994). Responses to the inquiries were documented and transcribed (Creswell & Creswell, 2019, p. 305). An audio recording device was used to capture the interviews. Field notes were utilised to uphold data integrity (Creswell & Creswell, 2019, p. 305). and they documented the responses to inquiries and any reactions that could not be captured by the recording equipment, such as nonverbal cues.

Each interview lasted approximately forty-five to sixty minutes. Light refreshments were offered to the interviewee for their attendance at the interview. Prior to the commencement of the interviews, a rehearsal of the interview process was conducted with an independent individual to ascertain that the duration was adequate and that recording methods would not hinder the interview.

The use of multiple data sources was justified to enhance methodological rigour though data triangulation. This strengthened credibility of the findings by reducing reliance on a single source and corroborating evidence across sources.

3.8. DATA RIGOUR

Trustworthiness

Trustworthiness in a qualitative investigation encompasses four criteria that must be fulfilled (Bryman et al., 2021, p. 44). These criteria include i) Credibility ii) Transferability iii) Dependability and iv) Confirmability. The data collection instrument maintained its credibility due to the procedures implemented in the study. The verbatim recording and transcription of the semi-structured interviews ensured that the interviewees' comments were accurately represented and trustworthy. Member verification was also employed to ensure that participants could clarify and confirm interpretations of responses. This minimised deception and ensured that results accurately reflected participants' experiences. Moreover, maintaining field notes ensured that unrecorded responses, including nonverbal cues, the interview setting, and researcher interpretations, were thoroughly documented (Creswell & Creswell, 2019, p. 305). Data triangulation conducted via interviews and document analysis also strengthened credibility by corroborating findings across multiple sources. These parameters guaranteed the data's reliability, contextual accuracy, and credibility (Bryman et al.,

2021, p. 44). The availability of this detailed description bolstered credibility since the depicted environment and provided perspectives make the results more authentic (Creswell & Creswell, 2019, p. 315). This may subsequently lead to the transferability of findings. Bias was mitigated through self-reflection, acknowledging how researchers' interpretations may influence findings based on their backgrounds (Creswell & Creswell, 2019, p. 315). Trustworthiness was enhanced by member verification and the use of co-coders, both well-established within the chosen research methodology and design, which helped to ensure confirmability (Creswell & Creswell, 2019, p. 315). The researcher also continually assessed their biases mitigate their impact on data collection and analysis to guarantee that facts, rather than bias influenced outcomes.

Credibility

For qualitative research to be credible, it must consistently produce reliable outcomes (Noble & Smith, 2015, p. 3). The integrity of this work depended on transparency and verification. A detailed record of study decisions, coding techniques, and data analysis was maintained (Nowell et al., 2017, p. 3). This allows future researchers to validate and trace the reasoning behind findings. Multiple coders independently assessed and categorised data throughout the thematic analysis to uphold consistency and reduce subjectivity (Cypress, 2022). A semi-structured interview guide ensured that participants answered the same questions, facilitating comparison and maintaining data consistency (Birt et al., 2020). An impartial researcher evaluated the technique, data collection, and interpretation to ensure the study's credibility (Berger, 2015, p. 13).

3.9. DATA ANALYSIS

The data-gathering phase of a case study often occurs without consideration for subsequent analysis (Yin, 2018, p. 114). Consequently, this results in several setbacks and obstacles. To address this, a definitive data analysis method was implemented. A well-structured database was crucial due to the numerous sources used in the case study. This database comprised four components: i) notes, ii) documents, iii) tabular materials, and iv) narratives. The comprehensive database streamlined data collection and improved reliability. Diverse data analysis techniques were employed for interviews and document analysis. The following points are delineated below.

Thematic analysis is recognised as a fundamental data analysis strategy employed in qualitative research (Bryman et al., 2021, p. 365). This method is adaptable and widely utilised, as it is not constrained by a particular philosophical framework (Bryman et al., 2021, p. 365). Thematic analysis generally detects, analyses, and delineates patterns or themes within a recorded data collection (Bryman et al., 2021, p. 365). This analysis typically comprises six stages (Braun & Clarke, 2006, p. 86): i) data familiarisation, ii) initial code generation, iii) topic identification, iv) theme review, v) theme definition and nomenclature, and vi) final report production (Braun & Clarke, 2006, pp. 87-93). Coding constitutes a crucial, frequently preliminary component of the research process (AtlasTi, 2024). The researcher used the open coding method to categorise the data according to their observations and judgments. This indicates that the encoded material was not displayed in its original form but was instead understood and represented differently by the researcher (Bryman et al., 2021, p. 398). Open coding employs an inductive methodology, signifying that theory is derived from data (Williams & Moser, 2019, p. 46). This necessitated that researchers refrain from entering issues with preconceived biases and maintain receptiveness to the insights that the data may disclose. Tesch (2013) delineates eight steps in the coding process as follows:

- Reading the transcripts and noting ideas to create a sense of the whole.
- Select an initial document and ask, “What is this about?” then note thoughts related to this.
- Complete this task for several transcriptions, then create a list of topics and cluster these topics together.
- Return to the data and abbreviate these topics as codes, checking if any new codes emerge.
- Use descriptive wording, then create categories from the codes.
- Decide on the abbreviation for each category and alphabetise them.
- Assemble the data in one place and perform the initial analysis.
- Recode if necessary.

Open coding represented the preliminary stage of coding, concentrating on identifying themes and concepts for categorisation (Williams & Moser, 2019, p. 46). Nonetheless, applying thematic analysis and open coding has several disadvantages to consider. The analytical technique may be subjective, influenced by the researcher’s perspective

in defining themes and assessing their significance (Bryman et al., 2021, p. 366). However, this was mitigated by employing co-coders to aid in the coding process and eliminate potential bias. Three methodologies for content analysis could have been employed. The chosen methodology was standard content analysis, which involves coding categories drawn directly from textual material (Bryman et al., 2021, p. 375). The researcher derived insights by analysing the entire data set and emphasising significant themes (Bryman et al., 2021, p. 375). These insights were used to generate codes, which are further categorised based on meaning (Bryman et al., 2021, p. 375).

These data analysis techniques were appropriate for qualitative and case study research. Both methodologies allowed for the systematic identification of themes through data analysis whilst preserving contextual depth and facilitated triangulation more effectively than alternative analytical approaches. Furthermore, both methodologies clearly delineated the requirements to attain the research objectives. Methodological rigour was enhanced by the involvement of co-coders, member verification, and evaluations by research supervisors. Reflexivity was applied to ensure that bias was adequately mitigated. Coding programs facilitated the diverse coding requirements associated with interview and document analysis. The chosen program for this investigation was ATLAS.ti. These strategies effectively combined to contribute to the trustworthiness of the findings.

3.10. ETHICAL CONSIDERATIONS

Ethical standards are paramount in the recruitment process, guided by a universalist philosophy of ethics (Bryman et al., 2021, p. 161). Ethical issues regarding the recruitment approach encompassed ensuring voluntary participation in the study and the option to withdraw at any time (Bryman et al., 2021, p. 165). The stringent confidentiality of participants' data, as well as information pertaining to the organisation, and the anonymity of individuals, operations, and entities was preserved. Full compliance with the Protection of Personal Information Act 4 of 2013 was ensured. Only publicly available information from the company was utilised; otherwise, approval was obtained for any material to be used and disseminated. The study did not jeopardise individuals, and no fraudulent methods were employed, with informed consent as a primary consideration. The study did not interfere with corporate operations in any way. The method of informed consent is detailed under section 3.6.

Safeguarding individual privacy in the research represented a major ethical concern (Bryman et al., 2021, p. 170). Protecting the anonymity and confidentiality of participants is a fundamental ethical concept in qualitative research (Petrova et al., 2016, p. 448). Confidentiality and privacy are two primary domains where ethical standards may be violated (Diener & Crandall, 1978). In the context of a universalist approach to research, these rights must remain unviolated (Bryman et al., 2021, p. 161). A violation of privacy represents a breach of trust and beneficence, necessitating protection (Petrova et al., 2016, p. 445). The requirement for informed consent did not diminish participants' right to privacy (Bryman et al., 2021, p. 170). Compliance with the regulations stipulated in the Protection of Personal Information Act (POPIA) of 2013 was mandatory. This guaranteed the safeguarding of the participants' privacy. The rights, needs, and values of the interviewees were protected during the interview and research process (Creswell & Creswell, 2019, p. 329).

To safeguard privacy and defend rights, the following actions were undertaken: i) The objectives of the interview and study were reiterated before initiating the interview. ii) Informed consent was formally recorded. iii) Transcripts were provided to the interviewee to promote transparency, consent regarding responses, reciprocity, and trust. The interviewee's privacy rights were prioritised in the study's reporting, and the research was conducted anonymously (Creswell & Creswell, 2019, p. 329). To safeguard participant privacy, the interviews occurred at a neutral location, with controlled access to the conference room (Petrova et al., 2016, p. 448). This ensured a secure atmosphere for the interview (Petrova et al., 2016, p. 448). A "Meeting in Progress" sign was displayed at the venue to maintain the integrity and confidentiality of the proceedings. Employees were identified by numbered codes rather than by name (Corti et al., 2000, p. 6). Job titles were not included (Bryman et al., 2021, p. 165). Field notes used the employee code instead of the employee's name to enhance privacy protection (Corti et al., 2000, p. 6). The researcher did not employ covert research methods, as this would have represented a violation of privacy (Bryman et al., 2021, p. 170). A final verification of confidentiality involved an impartial reviewer examining the study to guarantee that the subjects' identities remain indiscernible (Petrova et al., 2016, p. 451).

The accumulation and retention of data gathered during the study raises concerns regarding the confidentiality of this information (Bryman et al., 2021, p. 171). The

confidentiality of this information was safeguarded throughout the study and used solely for its intended purposes (Bryman et al., 2021, p. 171). The information was protected by the POPIA Act, and adherence to its terms was mandatory. This is emphasised in Section 14 regarding the retention and limitation of records. The collected data was securely maintained to ensure confidentiality (Petrova et al., 2016). To guarantee data security and proper management, the voice recordings and transcriptions of the interviews were electronically saved on a hard drive that was especially set aside for the study. Password protection ensured exclusive access to the researcher. The field notes were preserved in a secure, closed repository accessible only to the researcher. The documents used in the study were maintained in both electronic and physical formats. Electronic copies were protected by a password along with the audio recordings, while physical copies were safeguarded with field notes stored in a secure, locked location. Documents redacted firm information to maintain confidentiality (Corti et al., 2000, p. 7). Data was retained solely for the study's duration, with recordings and documents destroyed following the study's conclusion and retention periods (Petrova et al., 2016, p. 448).

CHAPTER 4 DATA COLLECTION AND ANALYSIS

4.1. INTRODUCTION

The purpose of this chapter is to present findings derived from eight semi-structured interviews, which were analysed using ATLAS.ti 25. Collected data was subjected to an iterative process consisting of coding, clustering, and refinement as part of the analytical process. This enabled the identification of recurring ideas, patterns, and narratives related to safety in a Gauteng gold mine. Codes were then reviewed for conceptual clarity and thematic cohesion. This, in turn, resulted in the development of key themes.

The authenticity of participants' perspectives is preserved through the extensive use of direct quotations. Some of these quotes have been condensed for clarity, while retaining their core meaning. In line with the case-based design, the presentation of findings and interpretation occur concurrently for each section.

In terms of data saturation obtained throughout the analysis process, main themes had stabilised by the fifth interview, and interviews 5-8 confirmed existing categories, with no new themes emerging, thus confirming suitable data saturation.

The codes that were derived are reflected in the word cloud below:

Figure 4-1 - Codes derived

The table below outlines the main themes and their corresponding sub-themes.

Table 4-1 - Data analysis themes

Main Theme	Sub-Themes
Safety Challenges in Gauteng Gold Mines	I. Physical and environmental conditions II. Ground control and standards compliance III. Equipment and rail-bound operations IV. Behaviour, mindset, and accountability V. Medical and psychological fitness VI. Supervision, organisation, and production pressure VII. Resistance to change and technology transitions VIII. Gender ergonomics and inclusive design
Systemic Interventions Implemented	I. Risk identification and mitigation procedures II. Training and competency development initiatives III. Management involvement and behavioural reinforcement IV. Technological and procedural innovations V. Seasonal campaigns and targeted responses
Factors Affecting Systemic Interventions	I. Behavioural and attitudinal challenges II. Employee engagement and ownership challenges III. Barriers to learning from incidents IV. Organisational and contextual constraints V. System design and implementation issues
Views Towards a Safety Framework	I. Aspirations for an ideal safety culture and framework II. Role of automation and technological advancements III. Incentives and recognition for safety IV. Enhancing education, awareness, and responsibility V. Pursuing zero harm

The following sections present these findings in depth. In keeping with qualitative research best practice, thick descriptions are provided, incorporating rich contextual detail and verbatim excerpts from participants' accounts. These descriptions were received from the interviews conducted with the participants that were performed without any disruptions. All participants were calm and composed during the interviews with no events occurring that heightened emotion or distracted attention from the questions posed.

4.2. SAFETY CHALLENGES IN GAUTENG GOLD MINES

Drawing on eight semi-structured interviews, the participants framed risk as i) physical and environmental conditions, ii) ground control and standards compliance,) equipment and rail-bound operations, iv) behaviour, mindset and accountability, v) medical and psychological fitness, vi) skills, training and loss of institutional memory, vii) resistance to change and technology transitions, and viii) gendered ergonomics and inclusive design.

4.2.1. Physical and environmental conditions

Participants repeatedly emphasised safety within the geological and adverse environmental conditions of deep-level underground mining. SI001 reported that: *"It starts with the physical underground conditions… whether you fix it today… it deteriorates over time."* Another participant, with extensive experience on deep-level gold mines, was unequivocal and stated that: *"It's seismicity which is the main safety challenge… how do we reduce the significance of seismicity on the mine?"* (SI007). Seismicity appeared both as background condition and as a proximate trigger of incidents. One manager emphasised that in ultra-deep contexts seismic events are *"mining-induced… not an act of God"*, and that elevated seismicity often signals a deviation from design or method (SI002). The interviews collectively suggest that seismic risk remains an inherent and unavoidable consequence of ongoing mining activity which requires continuous focus, rather than a hazard that can be fully eliminated without repeat incidents. The continuous focus placed on management and on response to seismicity will however ensure that injuries do not occur.

This aligns with recent analyses in mining environments, where mining-induced seismicity frequently shows increases in accordance with mining depth and whereby structural complexity has been identified as a persistent hazard (Sun et al., 2024, pp. 1-2). In South African gold mines based in Gauteng, seismic events reaching thousands per day are commonplace and reflect the unstable and stressed state of deep excavations (Scheepers & Malan, 2022, p. 120).

Thermal stress and ventilation were also mentioned as cross-cutting hazards. *"High temperatures underground"* raise physiological load and erode attention, requiring *"fitness levels [to] be on par"* and stricter adherence to *"procedures when going into*

worked-out areas" (SI004). Another cumulative strain is of *"aging infrastructures, the wear and tear… deepening projects"* alongside *"exposure to dust or chemicals"* (SI008). Although research on underground thermal stress remains limited, the physiological risks of high-temperature and heat exposure in deep mines are increasingly being recognised (Chai et al., 2025, p. 6).

4.2.2. Ground Control and standards compliance

Falls-of-ground (FOG) and gravity-related incidents were most frequently illustrated through the lens of ground support. Several participants linked FOG incidents to non-compliance with prescribed support standards. SI007 said *"If the guys did not actually comply to their support standard, then they'll have some safety risk"*. Another participant highlighted both omission of support and tokenism *"Sometimes the support would be there… but people would not be doing the prescribed pattern… they do the bare minimum"* (SI001). A rock-engineering-informed participant underlined that in workplaces that are affected by seismicity and gravity, panels *"regional support [must be] intact as per the design"* rather than installed *"for the sake of ticking a box"* (SI002). Tokenism can be noted as a potential symptom of employee disengagement. Pandita and Ray (2018, p. 195) note that this manifests with employees going through the motions to complete work without the required effort to ensure quality performance.

This emphasis on compliance to standard is supported by findings. Notwithstanding documented support plans, non-compliance remains a leading cause of rock-fall injuries. For example, Mark and Gauna (2017, p. 109) noted that even in supported areas, roof and rib falls continue to injure scores of miners annually, and that proper usage of support systems such as roof screen and rib bolting could drastically reduce incidents. This is also highlighted in the findings by Joughin (2024, p. vi) related to improved seismic management and ground control in South Africa. One of the improvements is attributed to the installation of steel mesh and a more dense support system, with the caveat acknowledged that substandard installation will exacerbate safety risks (Joughin, 2024, p. vi).

Research in a Zimbabwean gold-mine context by Masethe et al. (2025, p. 74) demonstrates how poor rock-mass quality informed by classification systems (RMR,

MRMR, Q-system) necessitated enhanced ground support design, reinforcing the importance of a design-compliant installation.

A recollection connected legacy excavations, current support activity and adverse safety outcomes. SI006 said:

> *"When you look at that one, it was just in a haulage where you don't expect anything to happen to anyone. But since these guys were drilling in an area or doing support in an area whereby there was a dyke and with the experience that we had, we never thought anything could happen to people, especially in the haulage. It's not like in the face or in the crosscut, but it was just in the haulage that was mined 12/13 years ago. And then actually whilst these guys were drilling in that dyke area, not drilling for production, but drilling to install support, it triggered a seismic event"* (SI006).

In this case old workings carry latent design debt, and "*stringent measures*" must be applied when re-entering such areas. Vigilance is essential, with even perceived lower risk areas layered with unknown risk. The environment is not static, it is dynamic and changes over time. Present practice will thus overlay inherited conditions. These changing conditions illustrate the importance of documenting geological and mining outcomes in old areas, whereby reference can be made and new methodologies considered and applied. The database of information kept provides insight into risks encountered in these older working places that are potentially revisited with improving economic conditions, or due technical constraints encountered in other operational areas of the mine.

Several participants also pointed to the importance of complying to standards to ensure a safe working environment. SI004 explained that:

> *"The same with if you look at the standards for support in a highly seismic mine, or a deep level mine that is normally highly seismic, there are specific support standards to protect people like for instance, the instope netting. And if you look at the incidents that recently occurred at a sister operation, it came out that the roof bolts weren't put in in the right way and it didn't hold up the net the way it was supposed to. So, it could not protect the people from the rock."*

This resonates with broader research on the limitations of monitoring and audit systems for support compliance. For instance, Rogachkov (2017, p. 42) reports on audits of ground support design conformity in coal mines, highlighting issues in installation quality and deviations from specification. Studies in South African mines using ground-penetrating radar and borehole inspections found that geological intersections and flat-dipping structures often undermined ground support systems, indicating gaps in both design and execution (Netshilaphala, 2019, pp. 29-34). This highlights the importance of understanding the design and reasons for standard of support installation, the importance of compliance to these standards, and creating visibility on this specific risk via risk management systems.

4.2.3. Equipment and rail bound operations

Equipment featured as both a source of risk and as a safety system. One participant contrasted these two sides, describing locomotives as safe *"when you do a proper hazard identification and assessment"* but dangerous when operators *"undermine it"* (SI001). Another offered a recent example at shaft bottom, where a fitter worked at height without *"guarding screens"* or a *"lifeline to attach your safety harnesses"* (SI003), indicating how risks are incurred when equipment is not utilised correctly or not respected.

Rail-bound equipment (RBE) incidents recurred in the narratives. SI001 said that:

> *"So one will also not take lightly that equipment that we are using, in this case the locomotives, if your behaviour is in such a way that you undermine it and you don't do a proper hazard identification and assessment before you are using it, it will end up being a danger to any individual who is using it. Locomotives only operate by running on rails, just like the locomotives on surface, then there is a chance whereby the rails conditions are not okay and then this is whereby a locomotive would do what you call a derailment"*

A participant recalled a loader derailment and a subsequent serious reportable injury:

> *"To date, we still don't understand what happened because no one, neither the team leader who was involved nor the witness can even today tell us what happened. It is the one where the team leader was pulled under the*

wheels of a loader and then he injured both his lower limbs. It was bad in the sense that the time it happened, it was in the early hours of the morning. But nobody knows what happened. Even the team leader, the other person who was there, they would say they were busy, the loader had derailed, and they were trying to push the loader. Then the next thing they heard a cry. But we are still having an individual who spent more than five months in hospital because he had fractures to the lower leg… That individual had to go to have more than 2-3 operations… He is alive today." (SI008).

Others were blunt about the asymmetry of mass and momentum of the locomotives. SI004 explained:

"And I think people working on a mine needs to have respect for the environment. They need to know that if you face a loco, the loco is most probably going to be the one that comes out best at the end of the day. Because if you look at a loco versus a human being, there is just no ways that the human being is going to come out triumphant should there be an incident between the two of them. But still you find people that walk on the wrong side of the traveling way. In many loco incidences in the past, you've heard that, it's either a person was standing against the sidewall, he thought there was enough space, but the loco caught him and he was pulled underneath the loco or it's people riding on the buffers of locos and falling off and then getting hit by the locos. It's very few times that, for instance, a loco incident would happen due to a failure of the equipment. It's more failure of human behaviour."

These instances showcase the seriousness and implications of what may occur in an environment where men and machinery need to work in conjunction daily.

4.2.4. Behaviour, mindset and accountability

The interviewees identified human conduct as a decisive variable. One framed "mindset" as the first challenge: *"People start… with the perception the mine is not a safe place… they expect injuries"* (SI002). Another named *"behaviour*" despite the existence of extensive procedures: *"Standards are there… but if we don't take these seriously and apply them underground… that goes back to behaviour"* (SI006). A third

emphasised accountability drift and lapses: *"Most people… think they are not accountable… somebody else needs to come and fix what's wrong"* (SI007).

Complacency amongst the experienced was highlighted: *"It's the most experienced people that fall victim… because they say, 'I've done this many times'"* (SI003). Participants described checklists reduced to paperwork as opposed to using them as dynamic tools: some *"fill [them] on surface… not addressing the right things",* with *"follow-up accidents"* despite nominal compliance (SI001). Others highlighted PPE neglect *("they're told, this is your PPE… but [they] haven't done justice to themselves")* (SI001) as a signal of everyday behavioural slippage that may occur.

These findings resonate with empirical studies of mining safety behaviour. Chen et al. (2022, p. 1) demonstrated that miners' safety behaviour is strongly determined by their work values and psychological empowerment; behavioural compliance and participation are mediated by internalised values rather than mere procedural enforcement. Yin et al. (2023, pp. 8-15) modelled how unsafe psychological states dynamically precipitate unsafe behaviour through complex interactions between individual psychology and organisational conditions.

4.2.5. Medical and psychological fitness

A narrative centred around a sudden incapacitation underground was a common thread in the interviews. In a recent case, a rock drill operator collapsed while lubricating a machine, later reporting he had heard a face burst and that rocks [were] on top of him, yet investigations found that no fall of ground occurred. SI002 explained:

> *"We had an incident on Sunday, where an RDO (rock drill operator) was on the face, and whilst busy lubricating his machine to start drilling, his colleagues, they just saw him falling. And it looks like he became unconscious and then he fell. And after falling, when he regained consciousness, he jumped up and then he hit his head against the Rock drill machine…. So, when this gentleman was now being interrogated as he was being asked, what happened? What injured you? His story is, I was busy lubricating my machine and then I heard a noise like a face burst and then all of a sudden, I saw myself having fallen, and my colleagues were taking rocks off of me. There were so many rocks on top of me, and they took rocks*

> *off of me. …. There was no fall of ground. There was no bump (seismic event), there was no face burst. Nothing. There were no rocks that had fallen on top of him, but he himself, his mind tells him there was a face burst, and he fell. With that investigation, one can see that the contributing factors here are the person is not mentally well or was not mentally well when they went into that specific stope"*

The same incident revealed how risk can be compounded in the underground environment when the crew *"put him against a jack"* rather than ensuring that he was placed on a stretcher and transported out of the mine - *"the jack is not stable… chances of him slipping and falling are very high"* (SI002). Other interviewees inferred a possible medical condition through the symptoms presented of *"possible epilepsy",* noting:

> *"I would think the contributing factors is ensuring that people are 100% medically fit to work underground because out of this incident that we've just had I am assuming that there is a medical reason like for instance, if you listen to what they said, they also said the individual was shaking and there was white foam coming out of his mouth. So, the first thing that makes me think of is possible epilepsy. And one of the biggest dangers was people that do have epilepsy is when they work with moving machinery because unfortunately with epilepsy you don't have control once you get a seizure or epileptic fit"* (SI004)

Beyond diagnosis, participants placed responsibility on supervisory vigilance: *"It's very important that supervisors keep track [of] psychological fitness… every morning"* and notice deviations in speech or behaviour (SI002).

Mine management frames the above incident as an incident occurring due to *"psychological fitness"* or alluding to an undiagnosed medical condition. However, a different mechanism is plausible when noting the sensory conditions underground. The RDO's own account stated *"I heard a noise like a face burst and then all of a sudden I saw myself having fallen"* together with the investigation's finding of no fall of ground, no seismic bump, and no face burst, points to a potential auditory trigger in the mine's soundscape rather than a geological event. This interpretation aligns with Asanda Benya's ethnographic work on the platinum belt, where she traces how the "mine

noises" saturate bodies and attention, and, at times, even influenced the researcher's own senses (Benya, 2017).

4.2.6. Skills, training and loss of institutional memory

Several participants linked recurring incidents to uneven skill and comprehension amongst employees. SI001 noted the limits of retraining certain individuals, despite formal processes:

> *"So now imagine for yourself there are those people that are trainable or coachable, and there are those who you cannot train, you cannot coach, you will think you are training, but you are doing it to yourself, you're not doing to them. This is where we found a contributing factor, but we think we have dealt with this and now we're going to bring our awareness to the same person who has got no skills or understanding on how to protect his own life beyond the day of coaching or training. So, we are still stuck with that few people that are uncoachable or untrainable. And then unfortunately our own systems are in denial to say that there are such people. Although part of training is to undergo Dover testing, majority of our people tend to understand this; to prioritise them and pass them and then pretend they are already made for the environment which is crucial for their life but in essence they are not"* (SI001).

Yaro and Sali (2023, p. 50) allude to these challenges within gold mining operations, and how the uneven skill levels and comprehension can be overcome by clear communication and tailoring this in terms of accessibility, simplicity and cultural relevance in safety training.

At the other end of the experience spectrum, he acknowledged employees on the edge of the retirement spectrum: *"I've worked with a man who is one of the group safety officers, but this man in no time will be going to pension, but his skills, it will be one of the best skills that if one can recommend additional persons to go through this, I'll recommend him"* (SI001). This potential loss of skill to retirement may either i) compound the current skills gap experienced by the interviewees or ii) present an opportunity for correct identification and recruitment of skills if the labour planning and recruitment process is handled correctly.

4.2.7. Resistance to change and technology transitions

Change management emerged as a distinct safety challenge. Several participants described a small but persistent cohort *"reluctant or resistant to adapting to change"* (SI003), requiring sustained *"coaching"* and repeated communication of *"the real reasons behind"* new practices (SI002; SI008). The most revealing examples concerned tool upgrades. One participant recounted the transition from leg-supported rock drills to thrust-leg systems, noting that some operators continued to *"support the thrust leg with their leg"*, as per how the prior device was used. This led to the employees sustaining injuries because the *"enormous force… compressed air"* now acts through the cylinder (SI001). Laig and Abocejo (2021, p. 43) illustrated the importance of change management in ensuring a structed approach is followed to allow changes to "stick", whilst Yaro and Sali (2023, p. 54) proved how effective communication is a lever of change management and can be the cornerstone of a safe working environment. These theoretical insights provide possible solutions to the resistance to change identified.

4.2.8. Gender ergonomics and inclusive design

One of the safety issues raised was the design of mine equipment that is still biased towards men. SI001 explained:

> *"We have now more women who are also employees or who works at the mine, and if you look at some of the equipment or whatever I can call it, they were designed one-sided to favour more men because back in the day, your underground environment was more focussed on muscular men. Now that we have women in mining when I must design a safety improvement plan, I need to take cognizance of that, there are these people that are working in there and I need to include them and then who knows if you include women in these things maybe the efficiency will skyrocket, will go up. No doubt you've seen everywhere with women who are now coming into the picture they add more values to the existing systems so that's one part that I would also like to consider"*

The practical challenge identified was ergonomic mismatch: controls, harnesses, and force requirements are designed by considering the average male body size and

strength, despite the changing workforce profiles. This participant framed the need for redesign as both a safety imperative and a performance opportunity for mines. The personal protective equipment that is a basic tool for use in the mining industry still favours male physiques. The absence of well-designed or fitted protective equipment may also lead to increase safety incidents as employees may not be as well protected as required.

Research supports this observation. Benya (2017) in an ethnographic study of South African mines documented how gendered assumptions were embedded in training and task allocation. For example, in winch operator training, women were frequently encouraged to observe rather than participate or relegated to assisting roles such as holding ropes or carrying tools. Men received direct hands-on practice and training in these instances. Instructors often framed these practices in biological terms, invoking ideas of female fragility and bodily risk (e.g., “the drilling machine vibrations will negatively affect your womb”), rather than evaluating individual competence. The embedding of this is mining operations suggest that gender-based equipment design is not necessarily technical or procedural oversight but rather a legacy artefact of historically male dominated production systems that have not evolved in line with gender diversification requirements which are also a legislated requirement in South Africa.

The exclusion of females may also influence the risk involved in mining operations. By not enabling them to be trained fully in the underground environment and understand how machinery operates purely based on a gender bias induces risk into the operating environment. By focussing on inclusivity, female employees may be able to introduce a new perspective to risk in the mining environment. It may also lead to improvements by focussing on the redesign of equipment and material to facilitate ease of use for females. This can then turn lead to improved safety outcomes by improving designs that may have historically been based on strength or force. Male employees will also benefit from this as easier operation of machinery should lead to less fatigue within a shift. Less fatigue incurred in a working shift will ensure that focus and attention on work and the surrounding environment is higher which will increase safety and operating performance.

It becomes an imperative to include women representation in the operational environment of underground mines, whilst looking past the traditional bias with which gender has been viewed. The benefit of increased engagement within this group also provides benefit to the culture at the operation with all employees included and facilitates trust amongst employees whilst breaking down bias and potential stigma as to traditional employee roles in underground mines.

The overarching challenges outlined are aligned to the reported safety incidents at the operation in the current financial year and companywide risks identified. At a companywide level these are referred to as i) the inherent mining environment, ii) FOG from hanging walls, iii) uncontrolled contact with machinery iv) lack of compliance and v) structural failures (Company A, 2024).

The recorded incidents for the prior year for [Mine A] are illustrated below in terms of agencies reported, confirming the importance of the discussed themes with them all appearing in various levels.

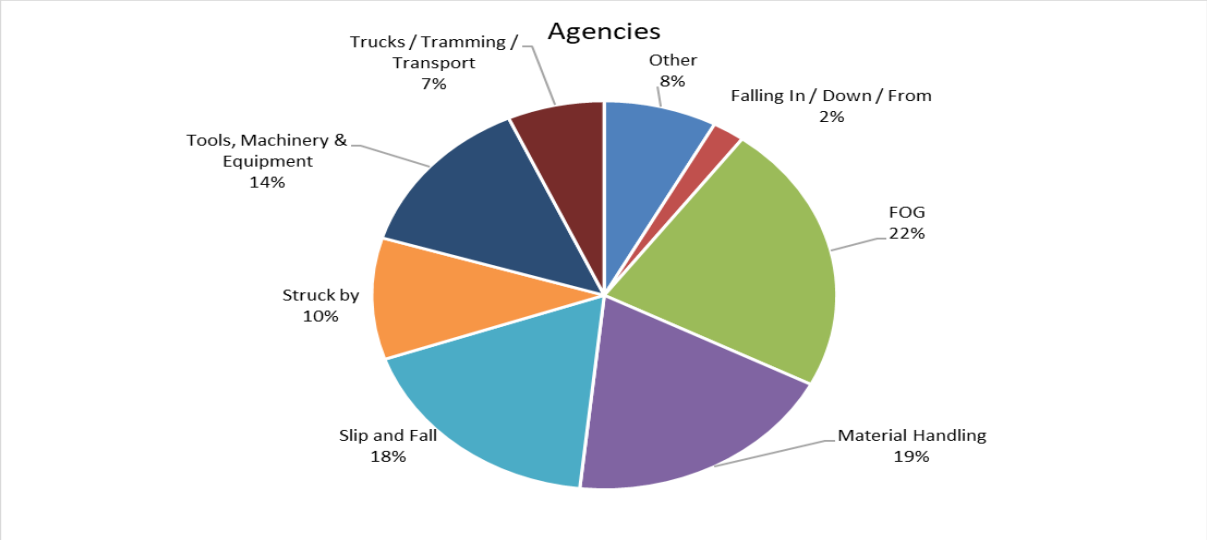

Figure 4-2 - Agencies of injuries

Source: (Company A, 2025)

4.3. SYSTEMIC INTERVENTIONS IMPLEMENTED

In response to the safety challenges outlined in Section 4.2, participants described the systemic interventions implemented within the gold mine to improve safety

performance. These responses centred around five interrelated sub-themes. These are i) risk identification and mitigation procedures, ii) training and competency development, iii) management involvement and behavioural reinforcement, iv) technological and procedural innovations, and v) seasonal and targeted responses.

4.3.1. Risk identification and mitigation procedures

Participants emphasised that entry examinations are a critical tool for ensuring crews collectively identify and address workplace hazards before daily activities commence. This team-based intervention fosters team accountability. A senior manager, SI002, stated that the entry examination *"has been introduced and interrogated several times to ensure that it is of the best quality… the crew is encouraged to examine and identify risks together in the workplace and address those risks systematically as they go through the workplace"* (SI002). The emphasis is on team risk management and acceptance before work can commence. The prescribed sequence *"go in from the top as a team, go to the bottom of the panel, go out the gulley, get to the centre gulley and all of them need to agree that this working place is safe"* was cited as a shared script for deciding whether conditions are acceptable (SI006). In principle, this approach operationalises distributed accountability, echoing arguments in the literature that interventions work best when they engage frontline workers as co-producers of safety. Nguembi et al. (2023, p. 9) found that there needs to be an assessment of activities on an ongoing basis. Korban (2015, p. 371) further argued that physical conditions and behaviour can be identified through the application of audit examinations of working places. Benson et al. (2024, pp. 6-8), in their study of health, safety and environmental interventions, found that effectiveness in high-risk industries depends not only on procedural controls but also on embedding practices that promote ownership and shared responsibility for hazards across teams.

Yet in this instance, the same participant warned of compliance erosion when OCR scans show only a team leader and *"a couple of guys"* signing the safe declaration, which hints at a slide from collective judgement to minimal sign-off (SI006). This aligns with Sedlar et al. (2023) and the qualitative review of the "normalisation of deviance" across high-risk industries. They show how formal safety practices can degrade into symbolic behaviour. This reduces their protective value over time when collective vigilance is substituted by procedural minimalism. Nyoni et al. (2019, p. 61) illustrated

how important these risk controls are and how they contribute to improved safety, making these slippages important to address. Improvements to risk management and efficacy of systems are facilitated by the presence of organisational factors such as leadership, safety culture, communication and supervision. This clearly illustrates system theory in practice with the systemic improvements made via risk reporting and visibility of risk improved or detracted by organisational factors.

Another systemic intervention identified was deviation management, which ensures hazards are documented and addressed systematically, enhancing transparency across management levels. SI002 explained, *"whatever deviations… are being recorded on paper and that paper gets signed with remedial actions… who's going to do it and by when,"* after which *"that same paper does not stay underground… it gets test scanned through the OCR… then it goes to central where it will be analysed, and the report will come as early as possible in the next morning to the supervisors, leadership and management as well as the executives"* (SI002). Tetzlaff et al. (2021, p. 201), in analysing retrospective safety reports in mining, argue that consistent documentation and escalation of hazards create the organisational memory necessary to sustain compliance and learning across levels.

Participants stressed that this loop is embedded within the operation. Areas with *"A hazards"* or *"critical control failures"* are stopped; during a *"high seismicity"* period *"about 3 months back," "quite a number of workplaces"* were suspended due to the increased safety risk (SI002). Kainat and Shahzadi (2021, p. 21) impart that exposure to risk can be controlled by compliance to appropriate standards. Baghaei Naeini and Badri (2024, p. 1) systematic review highlights that hazard identification and categorisation in mining remains most effective when linked to clear risk hierarchies and pre-agreed intervention triggers, ensuring responses are not dependent on individual tolerance but on shared standards.

Routine inspections and scheduled audits layer oversight and learning onto these processes. *"When a manager gets to the office in the morning… they can see the conditions of the workplaces of the previous night… to see the compliance of the entire operation"* (SI002). This daily routine is enriched by technical audits from rock engineering, ventilation, environmental and safety, which brings specialist scrutiny. Though it is qualified by *"a person who would go there once in 45 days or once in 30*

days is not as effective as the same person who's there every day" (SI001). This regular inspection routine is enshrined in the Mine Health and Safety Act 23 of 1996 in which section 2.19.3 details the intervals of oversight inspections through safety and strata specialists (Mine Health and Safety Act 29, 1996). Ismail et al. (2021, p. 6) identified leadership visibility and regular engagement as key factors that influence the safety culture in mining operations. It was also noted that safety systems will degrade without effective oversight from a supervisory and managerial level. This makes this particular intervention relevant to improving safe outcomes. Bisbey et al. (2021, p. 99) argue that safety culture develops through consistent reinforcement of expectations. This is done via integrating formal audits with daily practices to avoid gaps between policy and enactment occurring. Several participants connected these practices to the mine's wider Risk management system combining hazard identification, risk response protocols, and monitoring of unwanted events with entry examinations and planned task observations acting as the local enactment of that system. This is aligned to Bisbey et al. (2021, p. 104) who argue that safety culture matures when technical systems, behavioural expectations, and organisational learning are aligned. Widyanty and Kasmo (2019, p. 287) argue that the presence of a safety culture within mining operations influences employee motivation and job satisfaction, which thus improves safety outcomes.

4.3.2. Training and competency development initiatives

Training was narrated as a long lead and gradual socialisation into safe practice, avoiding quick induction methods.

> *"Any employees being employed at Company A… will go via a proper training induction at training… [then] a workplace induction whereby they are being inducted by their fellow employees with their immediate supervisors… This type of training happens over a period of time because we are using systems to check and balance, coaching, training, on the job coaching, and then PTO (planned task observation)"* (SI001).

This concept aligns with findings that training must be i) frequent, which ensures that behaviour is reinforced, ii) focused, to address core risks identified and iii) embedded into workplace routines. This approach helps to shape sustainable safety practices.

Yang et al. (2022, p. 15), in their systematic review of unsafe behaviours in coal mining, found that behavioural risk is influenced by individual traits and sustained, contextual training and coaching programmes that build situational awareness and reinforce norms. Adding to this is Milošević et al. (2025, p. 7), who identified that competency development and continuous education are critical factors for occupational health and safety performance in mining. Rapid technological and environmental changes demand that skills are continuously renewed rather than being subjected to once-off training measures.

The bow-tie approach was cited to anticipate and prevent unwanted events by mapping barriers and responsibilities: *"there's the whole bow tie and identifying unwanted events… preventing the unwanted event before it happens"* (SI004). In participants' terms, the value lies in teaching crews to interrogate controls rather than assume them. Interviewees' descriptions suggest that such frameworks are being translated into operational routines, reinforcing the emphasis on prevention through knowledge and systematisation. This is line with Badri et al. (2013, p. 12) who note that structured risk identification, mapping of barriers, and real-time monitoring prevent escalation and Kainat and Shahzadi (2021, p. 21), who recommend the establishment of a risk and review programme that accounts for a holistic safety approach.

Refresher training was mentioned as providing renewal and impetus, aligning workers with updated standards annually for regulatory compliance. SI001 explained, *"Everybody annually… will expire and that will also require you to undergo refreshers… we want individuals to go every 12 months for induction and refreshers every year, and we have found that to be working well in line with what the regulator… the inspectorate, as they enforce safety at mines".* This resonates with research showing that safety climate and behavioural adherence improve where organisations invest in continuous renewal and feedback cycles. Murphy et al. (2021, p. 1871) in their Montana mining case study showed that initial safety training improved knowledge, but ongoing refreshers and managerial follow-up were required to sustain climate change at scale. This aligns with the findings of Yang et al. (2022, p. 15), illustrating the transferability of this intervention in different settings.

Leadership capability was a notable focus. Participants observed that *"supervisors felt left alone,"* prompting two concurrent streams: [Intervention A] aimed at the whole

organisation, and *"the middle management and supervisory empowerment program which is meant for supervisors"* (SI001). Both were presented as practical: i) how to conduct work to standard, ii) how to intervene on substandard conditions and iii) how to use data to prioritise. Meetings were also re-designed to ensure fit for purpose. *"Safety meetings specifically for engineering had to be separated from the general safety meetings… to address the topics that are relevant and are prevalent to these employees daily"* (SI003). This segmentation treats engineering employees as having distinctive hazards rather than being recipients of generic messaging. Participants linked this initiative to better uptake. These initiatives mirror findings by Yang et al. (2021, pp. 6-8), who reported that role-specific training enhances hazard identification and decision-making among mining employees and is further improved when leadership is treated as a distinct competency that requires tailored support. Murphy et al. (2021, p. 1871) also stressed that leadership engagement and communication are integral to sustaining a positive safety climate, particularly in environments where supervisors manage complex and hazardous work. Joe-Asare et al. (2023, p. 1) note leadership capability and competency as a critical concern, with the most severe safety outcomes derived from leadership flaws, illustrating the importance of developing this competency.

Another key intervention mentioned was safety representative training, which empowers frontline workers to reduce safety incidents. Safety representatives were repeatedly credited with shifting the pattern of incidents and improvements made to the underground environment. They are *"trained, certified competent… sent underground… the eyes and ears of management,"* with one participant attributing a *"35% reduction of old types of incidences"* to their strengthened role in the industry (SI001). Some saw further room for improvement via risk-propensity assessments to balance crews: *"whether you have a good balance of people with different risk propensities onto a crew"* (SI004). The logic is that this would counter-act any higher risk taking with lower appetite for risk within working groups.

4.3.3. Management involvement and behavioural reinforcement

Participants described management engagement and behavioural programs, such as Visible Felt Leadership (VFL) and [Intervention A], as essential for fostering a safety culture. SI002 emphasised *"The visibility of the frontline supervisors, as well as*

leadership and management in the form of VFLs… to be visible at the workplaces and engage with employees to ensure that whatever deviations or whatever complaints… are being addressed accordingly". SI008 added,

> *"The intervention is the VFL, is to have managers who go out of their way to see; the active leaders taking time to visit the people at their own workplaces... To have a person of the CEO, even in his calibre to go into these bad places... being humble enough to show the people, the RDO (Rock drill operator) ... and tell them none of this could have been achieved without your safety."*

This intervention aligns with research on ethical and engaged leadership. The literature suggests that when leadership displays responsibility, trust, respect, and moral awareness, employee trust and discretionary effort is strengthened (Sugianingrat et al., 2019, p. 333). Leaders that act as role models reinforce behavioural norms and cultivate security and motivation among employees. This then supports compliance and creativity (Goestjahjanti et al., 2020, p. 72; Othman et al., 2018, p. 864). This in turn facilitates trust and hope with employees; leading to improved safety outcomes (Sundström & Nygren, 2023b, p. 325).

A targeted mechanism formalised this expectation as part of [Project Alpha]. The *"top 10 unsafe workplaces… were allocated to a member of senior management,"* with daily crew reporting *"for a period of a month"* until each workplace no longer appeared on the list. Weekly *"number plate"* close-out meetings then verified that actions promised were verified as completed (SI002). This distribution of ownership reframed hazardous working places as shared leadership obligations rather than solely a mining crew issue. The logic resonates with studies that link ethical and transparent leadership to heightened employee engagement and organisational citizenship behaviour, where employees go beyond minimum requirements because they feel valued and see leaders sharing risk (Chaudhary, 2019, p. 631; Uddin et al., 2019, pp. 62-63). Prinsloo and Hofmeyr (2022, p. 1) argue further that the tendency of supervisors to hold themselves and their teams accountable will lead to improved safety outcomes. This is seen in this instance with the removal from the top 10 list. Zhang et al. (2022, p. 14) further argue that the way that leadership approaches safety can have a positive

impact on reducing the quantity of accidents incurred, highlighting the relevance of this critical intervention and commitment.

[Intervention A] emerged as the most elaborated behavioural platform. One participant characterised it as a *"journey"* that connects the *"top and… bottom part (systemic and humanistic),"* using a visual route map and pictorials to widen participation. This helped to address comprehension given *"skills deficiency"* identified and facilitate storytelling to improve engagement and ownership (SI001). Sessions held amongst mining crews and supervisors *"afforded an opportunity to vent out… concerns,"* agree *"a specific strategy on how we are going to kill fires,"* and, once immediate concerns were addressed, rebuild trust and co-operation between employees and supervisors. Another interviewee framed the intervention as *"touch my heart, touch my brain,"* surfacing what people are *"really thinking while they're on the job"* and how frustration, pacing of work and short cuts lead to incidents (SI003). A manager stressed the naming of [intervention A] *"… to make it personal"* and the analytic workflow: data from entry examinations, inspections, and line reports are grouped by *"specific working area"* and repeating *"behaviour,"* after which teams *"review your system, review your process, review your strategy"* (SI005). A further thread linked [Intervention A] to accountability: *"we took guys to understand again their own responsibilities… risk response ratings… making sure… we… comply, or… improve"* (SI007).

This view is also affirmed though review of company documents. [Intervention A], represents an initiative to shift from a reactive to a proactive safety culture by understanding, defining, and managing risks. Proactive safety reflects the execution of culture transformation programmes to embed a safety culture based on leadership, development and engagement. This is a multi-faceted approach that integrates people, systems, wellness and assets. The process is facilitated and leveraged by i) communication, ii) continuous improvement via learning from incidents, iii) training to enable a learning mindset and self-discipline and iv) the use of competent and trained safety representatives (Company A, 2024a).

This approach reflects the argument by Pandita and Ray (2018, p. 194) that strong talent and change management, when integrated with clear communication will produce employee innovation, productivity, and commitment. This aligns with the broader evidence that a robust employee value proposition (EVP) which is built on

fairness, feedback, and opportunity, will keep talent engaged and committed (Pandita & Ray, 2018, p. 189). Ethical and visible leadership encourages employees to internalise organisational goals and exhibit extra-role behaviours (Uddin et al., 2019, p. 62). This leads to the creation of safer, more resilient operations, which is the key organisational outcome desired. By creating forums where frustrations, short cuts, and risks could be voiced, participants saw [Intervention A] as rebalancing relationships and enhancing co-operation. These findings reflect the leadership literature's emphasis on self-awareness and moral reflection: leaders who understand their own values and listen to employees are better able to sustain motivation and trust (Goestjahjanti et al., 2020, p. 80).

[Project Alpha] was narrated as a whole-mine turnaround that couples infrastructure fixes with behavioural activation. The operation *"did a total turn around on a shaft that was doing poorly… there was a risk of closing this operation due to… safety records,"* giving each place *"a nameplate that everybody knows… where they will be held accountable,"* and splitting work into distinct strands—*"[Intervention A] training with crews,"* targeted programmes for *"middle management… supervisors,"* and process-specific innovations so that *"you don't miss out on a specific group and cause a gap"* (SI004). Another participant described it as a *"multiple attack on all levels… started with infrastructure… went to behaviour… required systems and routines… with… outcome that was significant,"* sustained by project leads and *"constant feedback on progress… who was supposed to do what"* (SI005). Operational scheduling changes such as sending the deepest level (e.g., "113L first") down on the first cage were used *"to smooth out a lot of things"*(SI008). Woven through these accounts is a reframing of roles of supervisors who now wear *"two caps… one for safety… [then] production,"* and the critical role of safety reps who *"are the guards… helping operations"* (SI001).

The plan of project Alpha confirms how this initiative was focused on a holistic improvement of the operation. Data was analysed from the risk management system and crew satisfaction surveys to draw up areas that needed to be addressed to remove obstacles from making mining crews successful. These included a focus on i) increasing face time via shift scheduling and optimised transport, ii) improving infrastructure and equipment to ensure that mining crews had the correct tools available to them to conduct work safely, iii) the adopt a crew process, iv) review of incentive schemes and ensuring timeous payment, v) the development of a just culture,

vi) leadership development, development of others and effective change management, vii) establishment of routines for effective work to be conducted (Company A, 2024b). These themes reflect strongly in the feedback provided, indicating how this process has been operationalised and embedded. Project Alpha can be seen as an accelerated and focused process to ensure alignment with overarching company strategy and Intervention A. It represents the ownership and personalisation of the operation's safety challenges and response to them.

These approaches [Intervention A and Project Alpha] align with addressing the structural or hard issues and complementing them with behavioural interventions at the same time to ensure lasting improvement identified and recommended in developed countries (Lööw & Nygren, 2019, p. 443; Sundström & Nygren, 2023b, pp. 319-321). It provides a practical example of the dual focus that safety interventions should have that is grounded in the South African context and confirms the feasibility of implementation. It further also highlights systems theory, with the holistic focus on safety providing additional benefits in terms of an improved value proposition, buy in and engagement.

4.3.4. Technological and procedural innovations

Participants tied many gains to simple procedural anchors and selective digitisation which increases the visibility of deviations identified. Pre-use equipment checklists were described as non-negotiable: *"every equipment before it gets started or being operated it will be inspected by a competent person… That checklist identifies whatever that is not in order… If those are not in order, that's a no no. It's a big no go"* (SI002). Parallel "crew satisfaction" checklists taken "every second Monday" ask whether people are *"comfortable with the way safety is being addressed,"* creating a pulse on climate that can be compared with incident and deviation data (SI002).

Where locomotives are used, the operating system was repeatedly mentioned. *"The operation of the loco gets logged every minute, every second… you can download the information… and… see how many times the operators deviate from certain rules or procedures"* (SI002). Participants valued this not to be used as a surveillance mechanism but rather because it enables targeted coaching: a concrete link against

which to talk to a specific operator about a specific moment, emphasising the importance of awareness of behaviour and ensuring repeats do not happen.

Participants also referred to how safety is incorporated into the engineering operating model as a scaffold for safe job planning and *“a broader look… step by step plan a job so safely that we execute it safely,”* verifying that procedures and permits are in place, including for pressurised systems and work at heights (SI003). In several accounts, the operating model and how work was to be conducted was based on learning from incidents (LFI) platforms that record near misses and incidents, interpret causal patterns, and feed changes into procedures, training modules, and checklists.

4.3.5. Seasonal campaigns and targeted responses

Participants highlighted seasonal campaigns as addressing period-specific risks. SI001 explained*, "we will also have seasonal campaigns like when we are approaching the festive season... Majority of incidents happen through that period and then we are aware of that."* Messages are sharpened, supervision is intensified, and common pitfalls are rehearsed. *“Safety days”* suspend production to *“drop tools and focus only on making safe… we go into workplaces, correct what’s wrong, rectify what’s wrong”* (SI003). This response illustrates how seasonal changes may distract employees away from safe behaviour. As individuals working in an intensive industry, it is understandable how attention may be diverted when breaks approach and employees become excited about travelling home. This also reflects the social pressures that exist around these breaks, with expectations placed on employees to return home with gifts over December as an example. This may then divert attention further. These targeted campaigns acknowledge that these pressures exist and ensure that focus is maintained. It serves to reinforce employee behaviour in a high-risk industry.

4.4. FACTORS AFFECTING SYSTEMIC INTERVENTIONS

Following the systemic interventions described in Section 4.3, participants identified several factors that influence their effectiveness. They repeatedly returned to five clusters of factors: (1) behavioural and attitudinal barriers that divert attention away from risk; (2) weak employee ownership and uneven supervisor contact that depresses engagement; (3) breaks in the learning-from-incidents chain that prevent dissemination of information; (4) structural and contextual constraints, inclusive of literacy, knowledge

loss, workload, and union pluralism; and (5) system-design challenges, where complexity, perceived threat, or one-size-fits-all approaches blunt use.

4.4.1. Behavioural and attitudinal barriers

Participants located much of the difficulty not in a lack of rules but in the social psychology of repetition. Complacency was the repeated word. SI003 captured the pattern succinctly: *"the most prevalent one would be complacency… we hold constant safety meetings as reminders… However,… in some points you miss something or something is not highlighted often enough, then they become complacent on it and then you have a safety challenge."* It could be argued that this is a classic saturation challenge. When safety topics are rotated at high frequency without visible consequence management or renewed importance, these signals lose impetus and value. SI005 linked this to environmental conditions and behavioural adaptation: incidents *"usually… [are] driven by conditions that then drives behaviour, and the behaviour is either within standard or not to the required standard."* In other words, people align to circumstances that are presented to them, and not what the ideal standard is. This further outlines the criticality of a holistic systemic intervention that focuses not solely on compliance but also on how the intervention must be made dynamic to receive continuous attention from employees. It reveals the need for interventions to be matched by response and commitment to addressing safety concerns, as well as the importance of a safe culture within the organisation that may mitigate complacency.

A second narrative concerned value alignment. SI002 drew a clear distinction between corporate values and the uptake of those values by new employees:

> *"As mining companies, we have values but the people when they join companies, they don't spend time to align themselves or even to understand and interrogate the values of the specific company and confirm whether their personal values are aligned with those values of the company. I mean once our personal values are aligned to what the companies' values are like in Company A, safety as the number one priority and number one value"*

As noted by Bisbey et al. (2021, p. 93), organisational values underpin safety culture. Turnover of employees can undermine the development of a safety culture. New

employees that are not inducted and aligned to company values and culture will potentially make the overall safety culture regress.

4.4.2. Employee engagement and ownership

Engagement, according to participants, represents a bundle of ownership, morale, and contact. On ownership, SI002 was direct in his perspective provided: *"people [are] not taking ownership of their own safety… [they] believe that the supervisors… are the ones who are ultimately responsible."* He immediately linked diagnosis to method: *"Let them understand the disadvantage of us doing things the way we are currently doing… include them in the crafting of the methodology… Once you include them, then you end up getting buy-in… because [they] get ownership of the system."* The findings here align closely with the conservation of resources (COR) perspective, which suggests that employees are more engaged when they have access to and can maintain valuable resources (Hobfoll et al., 2018, p. 104). Constructs alluded to in the method proposed include autonomy, input, and supportive systems. These constructs have identified as valuable resources from prior studies (Halbesleben et al., 2014, p. 1338). In addition to this, employees who feel trusted and consulted perceive control and fairness which are two of the critical "fit" dimensions identified as antecedents of burnout (Shaik & Makhecha, 2019, p. 5). The presence of these dimensions can help prevent employee disengagement and burnout. Conversely, where control and ownership are absent, employees are more likely to externalise responsibility, which weakens safety behaviours.

Morale complicates the picture. SI004 provided a telling description of the sociological frame of mind of employees during challenging times: *"all the people I know working on a mine… come here to provide for their families… If you [are] under the impression that there isn't really a future… your mind is not looking at the risks."* This aligns with Milošević et al. (2025, p. 3) who found that organisational climate factors in workplaces positively impact safety satisfaction and thus safety performance. Conversely, continued poor safety performance influences the future of an operation, thus creating uncertainty in employees' minds about their futures, which may compound poor safety performance.

Depressed morale leads to the creation of absenteeism strategies amongst employees — *"people will find all kinds of ways not to be at work… they fix it with a sick note".* Compensation cycles of overtime maintain earnings whilst quietly increasing fatigue exposure. Production schedules that are not on target by the end of the week result in overtime worked over the weekend, which then leads to further absenteeism in the new week - : *"we are giving them an opportunity… to take days off because there's no loss of income… [they] make up that loss… over weekends"* (SI004). Such accounts reflect the job demands literature, where high workload, role stress and stressful events such as uncertainty drive physical and psychological costs leading to fatigue, stress, and reduced attention (Bakker et al., 2023, p. 28). The further consequence of this at a job level is that absenteeism will increase, depersonalisation occurs leading to increased turnover intentions whilst also increasing negative safety outcomes (Bakker et al., 2023, p. 30). Participants' comments on absenteeism and fatigue thus illustrate how resources may be squeezed with the intent to improve production outcomes, whilst this will have the opposite effect. In addition, when the future of an operation becomes threatened, limited perceived future security diminishes attentional capacity for safe behaviour.

It is thus important to consider how this cycle can be broken and morale improved when these circumstances are encountered. Ye et al. (2020, p. 9) clarifies that the creation of hope via leadership and engagement leads to an enhanced capacity to work safely. This underscores the importance of management in displaying leadership and commitment in challenging times, whilst communicating operational prospects clearly.

Contact with supervisors was identified as the third leg. SI006 relayed crews' complaints: *"we don't see the shift boss. We only see him that minute and then he's out… he does not even ask what the issues are… during VFLs."* The proposed countermeasure was incorporating regular engagement as a routine space for crews and shift bosses— recognises that engagement is conversational and regular, not performative and rare. Leadership studies stress that presence without listening is performative; employees interpret engagement by whether problems are heard, actions allocated, and deadlines met (Murphy et al., 2021, pp. 1869-1872; Sugianingrat et al., 2019, p. 334). Cotrina-Teatino et al. (2025, p. 7) further highlighted how effective this mechanism can be by approaching daily engagements as a mechanism to address

substandard risks, showing substantial improvement post implementation. Thus, the line between meaningful visible felt leadership (VFL) and drive-by management is drawn by responsiveness: ownership grows where voice produces change. This also aligns with job demands-resources theory that supervisor support, social interaction, and feedback are key motivational factors that enhance performance, satisfy basic needs for autonomy, relatedness, and competence, and foster commitment (Bakker et al., 2023, pp. 28-29). When employees experience reciprocal support, they tend to respond with loyalty, citizenship behaviours, and long-term attachment to the organisation (Uddin et al., 2019, p. 62). Conversely, a lack of meaningful contact can erode morale and reduce willingness to voice safety concerns. Across these accounts provided, messaging remains consistent. High demands that are placed on employees without matching resources to these demands will lead to stress and withdrawal. Involving employees in decision making, providing supportive leadership, and constructive feedback help to promote engagement, safety, and employee retention.

Throughout these narratives it starts to become clearer that the introduction of systemic interventions to improve safety needs to be met by rapid response to challenges identified. As systemic interventions increase, and the workload of employees to conduct activities potentially increases, or more data is made available to leadership on conditions in the working environment, the more critical the response becomes. Challenges must be addressed timeously and with the requisite care, otherwise this can lead to disengagement and loss of trust in return, which may then lead to adverse safety outcomes, despite improved systemic measures.

4.4.3. Barriers to learning from incidents

Participants endorsed learning-from-incidents (LFI) as a necessary backbone, but narrated breaks in the communication chain that keep lessons from reaching the most exposed workers. SI001 described the process*: "we have what you call the LFI… we sit around and we share… so that other operations… apply… to stop or eliminate similar incidents."* SI006 gave a sharp example of the gap in dissemination of information: *"you could see that it's not entrenched… We found operators underground; especially loco operators… that were not aware of the incident that happened in Mine B."* The issue, he argued, was superficial implementation: *"when you go to C level and below, you could see that it's not getting through… it just*

becomes a talk shop… a paper exercise… in the safety meetings." SI002 added the operational consequence: deviations remain unaddressed at the workplace, and *"later, we end up having a serious incident".* Similar communication barriers have been identified in other gold mining operations as documented by Yaro and Sali (2023, p. 33). This highlights the need for well-targeted, clear and simple safety communication within a mining operation to ensure that effective lessons are learnt and implemented, which will result in accident prevention.

4.4.4. Organisational and contextual constraints

Four key contextual constraints were identified: i) literacy, ii) knowledge retention, iii) supervisory workload, and iv) union pluralism.

Literacy was highlighted as a significant barrier. SI001 observed that *"there are those who cannot read and write, and there are those who can read… but cannot comprehend. And this is where the system of checklist comes with written and pictorial parts."* Where safety systems rely primarily on written English, sections of the workforce may be excluded, reducing the effectiveness of critical controls. In such contexts, checklists risk becoming procedural rather than functional. The use of pictograms alongside text was noted as a partial response, indicating the importance of designing safety artefacts that are accessible to employees with varying levels of literacy.

Loss of institutional knowledge was also a concern. SI001 emphasised the risk posed by retirements, noting that a *"group safety officer… will be going to pension,"* taking with him *"one of the best skills… [and] things that have happened from start up-to-date."* This reflects a well-documented knowledge management challenge in hazardous industries where tacit expertise is not easily codified, and without deliberate strategies for capture and transfer, organisations face weakened decision-making and reduced resilience when staff turnover occurs.

Supervisory overload emerged as another constraint. SI002 explained that supervisors *"are expected to do so much… They tend to… put everything else before safety and… not remember that… safety must come first."* Concentrating administrative and operational demands at the supervisory level dilutes their ability to provide coaching

and visible leadership. As a result, practices such as visible felt leadership (VFL) are weakened, and immediate production priorities will often override safety interventions.

Union pluralism introduced additional complexity. SI001 described workplaces with *"multiples of unions… a safety rep… from union A… address safety at the workplace where… majority are from union B… people see themselves in colours rather than in one colour of health and safety."* In these environments, safety messages can be interpreted through factional lenses, undermining coherence and peer leadership. Multiple representation does not automatically translate into stronger safety outcomes and can, in some cases, hinder collective commitment to safety goals if differing agendas are driven.

4.4.5. System design and implementation issues

Participants highlighted the political and social dimensions of system design, noting that the effectiveness of safety tools depends not only on technical soundness but also on user perceptions and organisational dynamics. SI001 recalled early resistance to the introduction of safety representatives, emphasising that opposition was not necessarily anti-safety but rooted in perceptions of surveillance and mistrust: *"people… did not see it as… user friendly… The supervisor saw this is a threat, so they would… oppose… [and] instigate [that] this must not see a mileage going forward.".*

Participants also stressed that safety strategies must be tailored to local conditions rather than applied uniformly. SI001 stated: *"Safety at Mine A… cannot be the same as safety at Mine B… each operation is tailored to its own way and its own design."* This perspective recognises the value of standardisation for company alignment and regulatory and procedural consistency. It also acknowledges and illustrates the importance of understanding the nuances of operations to translate this into site-specific practices to drive the ownership required that is essential for uptake and relevance.

4.5. VISIONS FOR CREATING A SAFE WORK ENVIRONMENT

In exploring what would constitute a safe working environment, participants articulated their visions for an ideal safety framework. Drawing from the systemic interventions and challenges discussed in previous sections, they highlighted aspirations for a

transformed workplace, the role of automation, incentives tied to safety, enhanced education and awareness, and the pursuit of zero harm.

4.5.1. Aspirations for an ideal safety culture and framework

Participants articulated ambitious visions of safety, often benchmarking underground work against the conditions of an office environment. The desired endpoint was an operation where safety is embedded and self-sustaining. SI001 said *"We want the underground environment to be like an office space… in the afternoon, they go home having not been injured, no scar… even if the supervisors are not there the operators… will be able to continue"* (SI001).

To enable this, participants called for a formal framework that couples risk identification with robust prevention and mitigation. SI002 highlighted the bow-tie method to map *"critical control risks"* before an event and post-event barriers to contain harm: *"analyse the risks before the incident… and even if it happens… what are other controls… not to allow the situation to get worse"* (SI002). Critically, SI003 insisted the framework must be authored from below. *"Safety campaigns should be bottom up driven… when remedial actions are implemented, it is seen as our concept, not the management's concept"*. This bottom up approach aligns with Bisbey et al. (2021, p. 105) who propose that a safety culture is developed over time through a bottom up process that accounts for consistent values, norms and assumptions regarding safety. Sundström and Nygren (2023a, p. 1018) argue further that it is important to not only rely on management's perspectives when designing and implementing organisational processes and structures, but the process must include employees at different levels.

Participants consistently emphasised the need to balance humanistic and systemic elements in safety management. As SI004 noted systems and permits that make risks and controls explicit, alongside behavioural platforms that transform what crews regard as acceptable practice. The fulcrum of doing so was identified as culture. *"Culture transformation… has to be led by management… and go right through the organisation… the culture you create will create that psychological safety mindset"* (SI005). Values matter only insofar as they are enacted: *"values… become a symbol… If the culture talks to the values, one will get that comfort that these guys are… walking the walk"* (SI005). This aligns with the framework proposed by De Jager (2019); and

the “systemising of activities”; and the “humanising of the response”. The basis of balancing humanistic and systemic elements in safety management is rooted in systems theory with clear evidence existing that the one leg of intervention affects the other. It also aligns strongly with recommendations from developed countries to focus on hard and soft measures (Lööw & Nygren, 2019, p. 443).

It was also stressed that such a framework requires permanent review: *“constantly looking at… limitations… a community of learning continuously… Safety… is not just a standalone item… it’s a continuous review”* (SI005). The principle is simple: without cycles that retire obsolete practices and embed useful adaptations, frameworks lose relevance to work done.

4.5.2. Role of automation and technological advancements

Participants framed automation as the most direct path to risk elimination in conventional mining by ranking tasks by exposure and moving people off the highest-risk ones first. *“Risk rank them… do we really want people there?… allow the machines… The machines can be replaced… the human life you cannot”* (SI001). They contrasted this with mechanised operations where exposure is already lower: *“trackless or mechanized… advanced… Here in the conventional there is still a level of risk… it’s going to take time to get the right types of equipment”* (SI001). However, the social costs were also mentioned that *“we sit with… 37% unemployment… once you get a machine, it will replace people… But… would not be proud to have killed a human being, rather… than machines”* (SI001). These ideas are relatively under-explored in the literature. Banson (2020, p. 14) attributed significant safety and productivity improvements to mechanisation in a gold mine. It was however further stressed that mechanisation may also lead to the inducing of labour unrest through the reduction of employees required. A further caveat is that the implementation of mechanisation may increase the potential for fatal accidents. Lööw and Nygren (2019, p. 442) however argue that whilst automation may reduce serious incidents, instances of trivial or low energy incidents may increase. These differing research viewpoints illustrate how important it is to balance safety, automation and labour requirements.

4.5.3. Incentives and recognition for safety

A clear theme was the need to reweight what the organisation pays attention to. *"The bonus schemes need to be more safety driven than… production"* (SI006). Participants suggested linking rewards to hazard management, not just to volume: *"areas with several A hazards… link bonuses to how many A hazards have been picked up… crews wouldn't like to have a lot… They will ensure… these A hazards are closed out"* (SI006). Others called for routine recognition to keep attention alive: *"for it not to die out… there would need to be highlights and rewarding… only on safety performance… in a more frequent and more… highlighted way"* (SI003). The ethos is not to *"pay people for working safe"* as a norm (SI001), but to use targeted carrots to signal what the system values when trade-offs bite. Yang et al. (2021, p. 8); Zhang et al. (2022, p. 15) affirm the positive use of incentive measures to increase worker's enthusiasm to avoid unsafe behaviours. This use of targeted incentives links back to social exchange theory and provides benefits for safety behaviour displayed.

4.5.4. Enhancing education, awareness, and responsibility

Participants wanted a workforce that understands risk at a practical level without assuming that formal qualifications are feasible for all. *"I would want to have everybody to have an 'underground degree', but I can't. But our continuous awareness processes… ensure that safety is… everybody's responsibility"* (SI001). The sticking point, they argued, is behavioural response: *"what spoiled it, it's the behavioural part… We need to up our game with regards to the response to risk"* (SI001). This aligns with the findings of Yaro and Sali (2023, p. 50) who acknowledge the varying skills and competencies of underground employees. Dodoo et al. (2023, p. 9) acknowledges a particular gap in terms of supervisory learning, which if management is aware of, can improve safety outcomes. This enhanced supervisory training has positive associations to safety behaviour, employee safety voice and safety stewardship, which will all enhance safety performance.

4.5.5. Pursuing zero harm

Participants insisted that zero harm cannot remain a slogan. *"When you talk about zero harm, we really mean zero harm, not… lip service… people are still getting hurt"* (SI001). They referred to national research capacity (e.g., CSIR) and to the industry's

current *“hybrid”* state *“still in the old ways, mixing with a new way”* (SI001) as grounds for both realism and ambition. These new technological improvements can help to remove employees from risk and drive new safer ways of work. This aligns with the approach in developed countries and the drive to adopt technology that drives improvement but should then be supplemented by behavioural change (Lööw & Nygren, 2019, p. 443). Committing to zero harm and living it as a realistic possibility is a critical step.

4.6. CONCLUSION

This chapter has illuminated the dynamic landscapes of safety in Gauteng gold mines through the lived experiences of eight participants. The findings reveal that persistent challenges in gold mines are rooted in the physical underground environment. Factors such as seismicity and heat make the operating environment challenging and increase the associated risk with mining activities. Behavioural lapses, supervisory pressures, and skills gaps compound these physical factors. Systemic interventions include the use of risk management systems, which derive information from the entry examinations, training programs, which detail compliance and reinforce behaviour, and visible leadership, which facilitates feedback, engagement, and learning, demonstrating proactive efforts to mitigate risks. Despite these interventions, factors such as complacency, low engagement, and literacy barriers can hinder their full efficacy and mitigate potential safety improvements. Participants’ visions for a safe future include cultural transformation that enhances safety culture, automation that reduces human exposure, safety-linked incentives that mitigate the influence of a production-first mentality, and a genuine pursuit of zero harm. These factors contextualise an approach that blends systemic and humanistic approaches with technology as an enabler to drive safety improvements.

CHAPTER 5 CONCLUSION AND RECOMMENDATIONS

The purpose of this chapter is to outline the findings from the study conducted, while illustrating the potential limitations of the study and focus areas for future research.

The stated aim of the research was to explore systemic interventions influencing the safety performance of gold mines in Gauteng.

To achieve this aim, four research questions and objectives were defined. These are outlined in the below table:

Table 5-1 - Research Questions and Objectives

Number	Research Question	Research Objective
1	What are the major challenges regarding the safety of the employees during mining?	To identify the main challenges related to employee safety during mining
2	What are the key systemic interventions adopted during the mining operations?	To reveal the systemic interventions implemented during mining operations
3	What key aspects of systemic interventions should be considered as influences on safety?	To explore the aspects of systemic interventions that affect the safety of mining operations
4	What adoptable framework can be inserted to enact an overall safety performance?	To establish a framework for overall safety performance

5.1. SUMMARY OF FINDINGS

The summary below frames the discussion around the four research questions and objectives with findings derived from the data analysis.

5.1.1. Research question and objective one – safety challenges

In terms of identifying significant challenges related to the safety of employees in mining operations, eight major themes were identified. These are outlined below:

1. The physical and environmental conditions. This is at the forefront of challenges identified with the working conditions, heat, seismicity, and ventilation, all presenting serious challenges.
2. Ground control and standards compliance is the second most frequent challenge due to the most adverse outcomes being associated with these incidents. Whilst measures are in place to mitigate this risk, ensuring compliance remains a challenge.
3. Equipment and rail-bound operations. Respect for machinery and compliance to the operating procedures still present significant challenges in the mining industry today.
4. Behaviour, mindset, and accountability present a risk due to how this may influence how work is approached. Complacency remains a challenge, and the work is accepted as routine when vigilance is always required.
5. Medical and psychological fitness present as a recurring risk that requires consistent focus, both from an organisational and supervisory perspective to ensure that employees are fit for work and that any noticeable symptoms are observed and acted upon.
6. Supervision, organisation and production pressures. A production first mentality, combined with union allegiances and weighting of incentives all contribute to actions taken that may not give priority to safety.
7. Resistance to change and technology transitions. Change is still met with significant resistance. This inhibits technology transitions and will hinder changes implemented that will not result in the expected benefits being seen.
8. Gendered ergonomics and inclusive design. Equipment is still designed for male employees, despite the increasing number of women working in gold mines.

The eight participants highlighted that safety challenges cover a wide range of aspects. It confirms that the risks posed are a blend of physical and behavioural, illustrating the critical need for their incorporation into integrated safety frameworks. Whilst focus is traditionally placed on the risk and mitigating factors in terms of physical risks, it is important to increase this focus by formally acknowledging the behavioural aspects and pressures that increase risk into the safety systems.

5.1.2. Research question and objective two – adoption of systemic interventions

In addressing the second research question and objective, the data analysis revealed an array of systemic interventions that have been implemented. These are:

1. Risk identification and mitigation procedures. The primary tool from a systemic intervention perspective is the implementation of a robust risk identification system that incorporates feedback from end users such as the mining crews on a frequent basis. The process involves the use of checklists which are adapted both in a written and pictorial manner to enhance awareness and understanding. These identified risks are monitored with close out actions required. Enhancing this is the response to risk protocol that is followed which requires intervention by line management and other senior management, with regards to the type of risks Identified and Intervention required.
2. Training and competency development initiatives. A meaningful intervention is the way that employees are trained and onboarded into roles. An integrated training assessment process is followed that first covers a theoretical basis of work to be done which is then followed up by on-the-job training before competency can be certified. This holistic approach ensures that risk of the working environment and that which is posed to self and others is fully understood.
3. Management involvement and behavioural reinforcement. A critical intervention is the involvement of management in interventions and the display of commitment to achieving stated objectives. Management has taken ownership of the interventions implemented and led the process in this regard. From adopting crews until working places have reached a safe rating to driving risk response and the facilitation of culture change, management commitment has been at the forefront of interventions. Behavioural reinforcement is another critical level implemented with the focus on creating platforms for engagement, learning and culture development.
4. Technological and procedural innovations. The digitisation of data has played a clear role in establishing visibility of risk within the mining operation. Adapting and enhancing procedures with new information, for instance with loco operation is a testament as to what can be made possible.

5. Seasonal campaigns and targeted responses. A common intervention presented is aligned with calendar events and cognisance is taken as to how to respond differently in these times, noting the impact that extended breaks may have on mental state and focus of employees.

The interventions showcase how the approach followed does not just rely on the introduction of a systemic initiative to improve safety outcomes. Whilst these interventions are the basis of improvement, technology and human aspects are leveraged to ensure that interventions gain traction and ownership amongst the employees.

5.1.3. Research question and objective three – influence of systemic interventions

The systemic interventions that were implemented all contributed to different spheres of safety at the operation. The interventions and the areas of influence that they affected are discussed below:

1. Risk identification and mitigation procedures. This creates awareness of risks and enables reporting from both a system and crew perspective, fostering engagement and contributing to a reporting culture, which is a key pillar of safety and just culture.
2. Training and competency development initiatives. This intervention has ensured that employees undergo correct training and induction before commencing work, allowing acclimatisation to the way of work conducted and allowing new employees to be immersed in the culture of the operation and begin adapting before starting work. Further, by focusing on supervisory leadership as well, safety culture is enhanced by ensuring that correct behaviour can be modelled. This in turn drives safety stewardship throughout the operation at both a supervisory and employee level.
3. Management involvement and behavioural reinforcement. Achieving a safety culture is a critical intervention as highlighted by the participants. Interventions such as improved employee behaviour and improved safety outcomes were frequently highlighted as being the most influential in driving a safety culture. Management commitment, presence and engagement with the workforce are fundamental to making changes to culture and behaviour.

4. Technological and procedural innovations. The digitisation of data has led to improved visibility and the daily generation of effective data. This facilitates the reporting culture and strengthens the safety culture. The daily close out and routines based on the information fosters accountability and drives decision making and response at the correct levels.
5. Seasonal campaigns and targeted responses. These seasonal influences ensure that focus is kept in times where employees could be easily distracted. It facilitates the improvement of culture by acknowledging and showing care to employees with gentle reminders of the importance of safety during these periods. It also drives improvements in employee behaviour by providing focus during critical areas and reinforced awareness during times that employees may be distracted.

There are barriers to systemic interventions that will mitigate or limit their influence. These are discussed below:

1. Behavioural and attitudinal barriers. These barriers were described as those which cause individuals to lose focus to risk. Complacency is a particular concern noted. To overcome this, ways to refresh safety messages need to be sought and implemented. Established ways of work should be reviewed and compliance checked to mitigate check box exercises. When concerns are raised with regards to physical conditions, these should be actioned critically as leaving these to linger contribute to employee disengagement, which may present as an attitudinal or behavioural barrier. This barrier can be addressed by efficient line management, regular engagement and management action.
2. Employee engagement and ownership. This is a critical concern whereby employee response to safety interventions is poor. The role of employee morale is critical, illustrating the importance of clear communication and engagement. The role of management in creating hope within a workforce becomes a clear mechanism to overcome this barrier.
3. Barriers to learning from incidents. The dissemination of critical information is made ineffective by communication that does not take place. If engagement and interrogation do not take place, no learning will happen, and no process improvement will be made.

4. Organisational and contextual constraints. Four constraints were identified which are i) literacy, ii) knowledge retention, iii) supervisory overload and iv) union pluralism. These barriers mitigate dissemination of information, compliance and discipline. The necessity of empowering supervisors and work crews through interventions that align them with a common purpose comes to the fore in overcoming these issues. Collection and communication of data via easily interpreted mechanisms is of particular importance in addressing potential communication gaps.
5. System design and implementation issues. Often when systemic interventions are instituted, there is no cognisance given to the nuances at different operations and potential differences in way of work or culture. This stresses that ownership and personalisation of broad interventions will become essential to mitigate this shortcoming.

The influence of systemic interventions is far-reaching in facilitating a safety culture, changing employee behaviour and improved safety outcomes at the operation. The most influential interventions were related to i) management involvement and behavioural reinforcement and ii) risk identification and mitigation procedures.

These two priority areas are made up of interventions that focused not only purely on systemic interventions but embraced the human aspect. Both these interventions formed part of strategy at an organisational and then operational level. As such they were based upon structured implementation processes and change management, which differentiates them from singular focus measures and perhaps illustrates why they achieved success. They were adopted and driven by a strong sense of ownership of senior management and personalised so as not to remain at arm's length, but rather woven into the fabric of work routines until it became the way of work. They were able to overcome the barriers that were identified that detract from systemic interventions and moved forward as influential safety interventions that became institutionalised. These interventions were effectively communicated throughout the operation and by focusing on culture transformation to embed safety principles, alignment is created in terms of implementation and execution. This shifts the goals to a more common footing, with benefit for all parties involved. The involvement and engagement between management and mining crews illustrates the efficacy of involving them in the design and execution of systemic interventions as the end users of the system. The leads to

the recommendation that systemic interventions should be complemented by humanistic measures to enhance influence, whilst acknowledging that the implementation of a systemic intervention in isolation is potentially insufficient to provide sustained changes to safety.

5.1.4. Research question and objective four – safety framework

Improved safety outcomes within the mining industry and the pursuit of zero harm, whilst ambitious, continues to be driven throughout industry. To facilitate this progress, the following recommendations are provided and are to be inserted into a safety framework to help achieve this critical imperative.

The first step is the articulation of zero harm as an achievable target. Whilst the mining environment has risk and this is acknowledged, mitigation processes are in place to prevent negative safety outcomes. The principle of each day being a safe working day needs to be ingrained in all employees with clear commitment to this achievement. This vision should be the first step of organisational and operational strategy.

The priority principle for the safety framework that needs to be in place is a robust risk management system. As noted within the interviews and the process of Project Alpha, these systems provide data which can be used to monitor the operation holistically through the identification of risk. The most pressing advice imparted is that the system needs to be designed with engagement from the end users and empowering them to design and use the risk management enhances its overall effectiveness. This in turn strengthens employee voice and engagement, yielding further benefits to operations. Incorporating crew satisfaction measures into the broader risk management system will also enhance the coverage of leading indicators.

A further critical component of the risk management system is the digitisation of data which i) creates clear visibility of risks and actions required to close out, ii) facilitates the creation of a robust data base of workings that documents reasons for workplace stoppages and informs strategy if these places are revisited.

The next critical component of the risk management system is the response to risk. A risk management system is enhanced by the response to risk of management and employees. Issues and hazards that are raised should be promptly addressed within

an agreed upon timeframe and by the correct levels of supervision based on the circumstances reported. By addressing issues and hazards in time, trust is fostered between mining crews and supervision. This breaks down a critical barrier and ensures care is brought into the work relationship and employee voice strengthened through line management action. This lays effective groundwork for culture transformation to a safe culture to be actioned and accelerated. This is further facilitated by lessons from incidents that disseminate relevant information to the operation, enabling learning to take place and the prevention of repeat incidents.

Interventions should be targeted and inclusive of crews and supervision. It is critical that both these layers are not excluded from the design of a safety framework and that the employee voice of these categories remains strong. Cognisance needs to be given to the levels of literacy and how training mechanisms are structured to enable employees to understand work clearly. There should be an acknowledgement and support for the work pressures that individuals encounter, particularly at a middle management level. These individuals may represent a missed layer as vast pressure is placed on them in terms of work deliverables, with competing pressures distracting from ultimate safety improvements. These employees need the requisite support and coaching to be able to function optimally at this critical level.

The risk management process should be a part of the broader culture transformation towards proactive safety at a mining operation. Identifying and responding to risk, the involvement of employees and the commitment to addressing concerns builds trust and lays the groundwork for an effective safety culture at an operation.

Incentivisation of the safety response is the next critical component. In aligning with the importance of safety, incentive agreements should reflect this. Incentive schemes contain a safety component, but in the perception of the participants of this study, production takes priority. Targeted incentives can facilitate a stronger focus on safety. The benefit of improved safety outcomes should lead to improved production outcomes via decreased stoppages. It acts as a motivator for safe behaviour.

Training and development processes should begin with a clear focus on safety, and recruitment strategy to ensure the correct skills are in place to avoid shortcomings identified. Training should be done regularly, and must focus on more than just

compliance, and should also be dynamic to ensure competence in the workplace. This will reinforce the efficacy of training measures.

Lastly, focus should be placed on continued improvement. Safety does not stop, and it requires continued focus. Processes should be constantly reviewed, engagement meaningful and awareness of safety maintained. Barriers highlight how easily slippage occurs, and the above items help to position safety as a reinventive process that is always given top priority.

The framework follows logically from vision to strategy, to implementation via systemic and humanistic interventions while monitoring and renewal take place. This ensures that the framework remains dynamic, up to date and responsive. By framing it in strategy and entwining risk management and culture transformation, improvements to safety can be made.

5.2. THEORETICAL IMPLICATION

The research contributed to theory by extending the application thereof to the domain of deep level gold mines in Gauteng.

Systems theory, as outlined in the conceptual review, is premised off changes in one area influencing another due to the interconnectivity of these areas, with changes in a specific area substantially impacting the whole (von Bertalanffy, 1950, p. 5).

Benson et al. (2024, p. 3) elaborated on the relevance of this theory when introducing interventions within a health and safety environment. The application of systems theory principles can ensure that organisations adopt a comprehensive approach to health, safety and the environment, leading to enhanced overall performance. This is indeed confirmed by the application of systemic interventions within the gold mining environment.

Interventions such as risk management systems, process, policy and strategic revisions, and technological innovation also play an influential role in not just determining safety outcomes, but rather behavioural or cultural outcomes as well. Conversely, focus on these humanistic aspects plays a role in improving systemic outcomes with systemic outcomes improved by the focus placed on leadership, commitment, ownership and communication. This shows mutual dependence between

these two aspects, and a systems perspective is supported whereby feedback loops are utilised to drive and sustain continuous improvement.

The research also provides further insight into Human Relations Theory, illustrating that employee engagement and participation are not only motivational levers, but are also structural enablers of improved safety outcomes within mining operations. This focus can increasingly highlight how social dynamics can improve safety outcomes, with a progressive shift in safety management from a systemic base only to increased touch points of humanistic aspects.

5.3. MANAGERIAL IMPLICATION

The study provides several managerial implications for improving safety in gold mining operations. As an overarching first principle, zero harm should be embedded within organisational strategy. This means that safety initiatives need to form part of the broader business strategy and take precedence as a reporting and performance dimension. The guidance premised on this first principle of zero harm is outlined below.

The first guidance provided is that an integrated approach to safety should be adopted, combining both systemic and humanistic measures. Systemic tools, which include risk management systems, safety frameworks, processes and strategies need to be supported by leadership commitment and visibility, communication and workforce engagement and participation. Interventions conducted without these measures will be less efficient and will not be easy to become embedded within an operation. These multiple factors working together also facilitate an improvement to employee value propositions, which further drive improvements to productivity, efficiency and talent management within an organisation.

Technology should support automation and reporting of information from risk management systems. Whilst this may require potential investment from mining organisations, the benefit in terms of building and maintaining a database for safety is greater in potential value. In this regard, selective digitisation can be implemented for risk identification and monitoring for maximum benefit.

Leadership must actively focus on ownership and accountability for safety outcomes. The visibility of leadership and inclusion of employees in safety decision-making enhances engagement and reduces resistance to the systemic measures adopted.

Investment in training and competency development should be done in conjunction with a strategy to retain institutional knowledge. This becomes more critical the higher the average age of the workforce becomes.

Incentive schemes should be reviewed and aligned with safety taking precedence. Historical production's first incentive schemes should be reviewed and revised.

Holistic management systems should institutionalise feedback loop where lessons learnt are embedded within the operation and drive continuous improvement. This includes learning from incidents, risk management systems and audits, as well as employee feedback. This drives not only a safe but a just culture within the operation.

These implications provide guidance for policy and decision making within mining operations, with these key focus areas providing direction for where constrained resources may be directed to maximum benefit.

5.4. RECOMMENDATIONS

This section presents recommendations derived directly from the findings of the study which are aligned with the research objectives. To enhance clarity of the provided recommendations, they are structured into short-, medium- and longer-term actions that can be implemented progressively to improve safety performance of gold mining operations.

Short term

The short-term actions focus on improving response to risk, behaviour and communication practices. These include the prioritisation of management visibility and engagement at workplaces. Interaction should take place regularly between management, supervisors and mining crews to reinforce safety expectations. This regular interaction facilitates trust, particularly when hazards raised by crews are responded to timeously.

Risk identification and response processes should be streamlined to ensure that actions raised are closed out timeously. Accountability for actions required should be clear, with strict compliance to agreed safety response timeframes. This places confidence in the information provided by the safety reporting system.

Safety communication methods should focus on reaching all employees via visual tools, simple messaging and frequent reinforcement. This overcomes potential literacy or knowledge retention challenges.

Refresher training should be held at frequent intervals to address behavioural and attitudinal barriers. The main concerns to be mitigated are complacency and risk normalisation.

Medium Term

Medium term recommendations focus on the embedding of systems, development of leadership capabilities and aligning the organisation to improving safety.

Risk management systems should be digitalised to enhance the visibility of hazards, track close out actions and enable analysis to be conducted. This process should be selective and focus on highest value areas

Incentive schemes should be reviewed, and safety prioritised alongside and not be subordinate to production incentive schemes.

Investment should be made in supervisory development and coaching to provide them with the key skills to prevent supervisory overload and remove this barrier from safety initiative implementation. Improving skills at this level will improve consistency and communication at the working places.

Feedback and learning mechanisms should be embedded within operational routines with processes such as learning from incidents, audits, and employee feedback formalised to inform continuous improvement and prevent reoccurrence.

Long Term

Long term recommendations focus on transformation, sustainability and innovation once a stable has been created by the prior interventions.

Long term culture transformation programmes should be instituted that focus on shifting safety management to proactive from reactive.

Technology adoption of advanced technologies such as automation, internet of things applications and artificial intelligence can be progressively explored to strengthen leading indication analysis and support earlier interventions and reduce risk exposure.

Equipment design and work practices should be reviewed regularly to determine whether approaches are inclusive and ergonomic to all employees. Design of systems and tools to accommodate diverse employees will reduce risk further.

Safety frameworks should be reviewed on a regular basis to ensure relevance and effectiveness in response to operational challenges.

5.5. LIMITATIONS OF THE STUDY

Whilst the current study offers lessons, it is limited in certain aspects. These include:

- A single case is used for the purposes of the study, which may limit transferability or generalisability of findings despite the measures put in place to mitigate this.
- The focus of the study is on senior management and their perspectives, which may limit the views provided in the study.
- Due to the case study methodology adopted, it is difficult to replicate the study in other settings.

5.6. RECOMMENDATIONS FOR FUTURE RESEARCH

The study illustrated clear areas that can be examined in future studies. These are outlined below:

1. Conduct more case study research on the safety performance of mining operations and what was done to improve the current position. This can be done via comparative multi-case study designs across multiple gold operations or gold mining companies. Practical, operational research is required to understand how operations approach safety and how best practices can be adopted and transferred to other operations. Nuances between operations can be identified to understand what the influence of these differences may entail. Commonality in approaches and learning may then be facilitated via

differentiating between what may be an industry wide approach and what should be based at a single operational level.

2. Examination of the congruent development of systemic and humanistic interventions and the associated benefits that this may bring to other mining operations. This may be done via quantitative validation of integrated approaches via surveys to test the relationships between the various interventions. Quantitative validation enables the statistical examination of the influence of systemic interventions on safety performance.
3. Culture transformation remains a key initiative in the mining industry and at individual operations. More research in this area is required. As culture transformation has a longer time frame for implementation and embedding within operations, longitudinal studies that highlight implementation methods, shortfalls and successes will be beneficial. These studies are recommended to take the form of longitudinal studies to examine the culture transformation over time.
4. The role of trade unions as an enabling factor in culture transformation can be examined as a key stakeholder and facilitator within the mining industry. Comparative studies amongst operations and case studies should form the approach to these studies.
5. The influence of morale on safety and productivity can be explored, particularly with operations approaching end of life or experiencing troubled times. This can take the shape of a quantitative study with morale as a mediating variable between organisational pressures and safety performance.
6. The role of automation in improving safety outcomes in the South African context can be explored, due to the small footprint of implementation. The potential effect of this on employment can also be investigated. Pre and post implementation windows should be investigated to determine the impact of automation, whilst also exploring the implications on employment and skills development required by employees.
7. As highlighted by the study, improvements have been made by digitisation, but how this can be leveraged for operational benefit through internet of things and artificial intelligence can be investigated. This will enhance leading indicator analysis. Empirical studies examining the impact of predictive analytics, real

time monitoring and data driven decision making may provide further insight into proactive safety or risk management.

8. Lastly, as technology is advancing rapidly, the concept of wiring the mine combined with the application of internet of things and AI data analysis on leading indicators to prevent injuries should be a logical progression as these innovative measures increase uptake in the industry. For this area, case studies are recommended to document the findings from practice to elaborate on feasibility, effectiveness and scalability.

5.7. CONCLUSION

This study aimed to explore the influence of systemic interventions on the safety performance of gold mines in Gauteng and makes several important contributions to theory and practice within the field of safety management within this context. The study contributes insight into an under-researched context, namely deep level gold mines within a South- African context. Whilst safety management and systems theory are well established within literature, there remains limited qualitative literature that explores how these principles are enacted in practice. This is particularly true within the context of deep level gold mines which are characterised by seismicity, environmental challenges, labour and union complexity. By drawing on the experience of senior managers, the study contextualises existing theory in a practical setting.

The study further offers a conceptual contribution of systemic and humanistic interventions in the sense that these areas or not independent or sequential, but rather mutually reinforcing components of an integrated safety system. These areas are often treated as parallel or individual constructs, this study shows that systemic interventions gain more traction and influence when combined with humanistic elements such as leadership, ownership and employee engagement.

The study contributes practice-based knowledge to provide recommendations for a safety framework that can be adopted. This framework is grounded in operational experience and incorporates various aspects of risk management, technology, leadership, culture whilst striving for continuous improvement. The framework aims to translate the aspirational target of zero harm into an operational strategy to improve safety performance.

The study concludes that management involvement and risk identification and mitigation processes are the most influential in shaping safety outcomes. This study extends current literature by showing that the effectiveness of these interventions lies not only in design and implementation, but also the ownership, response to and integration into established ways of work. This provides guidance of how safety measures or interventions may be institutionalised at mining operations.

In closing, safety remains a nuanced topic, and it requires continued investigation to make future changes to address the goal of zero harm. Whilst significant progress has been made in improving safety outcomes, the work done to improve safety cannot cease. Improving safety outcomes strengthens operating efficiency and the social license to mine.

The progress that has been made in improving safety outcomes is based on a strong theoretical base as outlined in this case study. Further success can be obtained by leveraging technology, driving culture transformation and ensuring personal ownership and commitment of all employees. By pinning these on a risk management system that holistically approaches risk by acknowledging the risks involved with work itself and the social, behavioural and organisational pressures that employees face, a stable ground for this is put in place to sustainably change culture at an operation. This will result in zero harm being an achievable target.

The approach mirrors established literature in developed countries whilst illustrating how these approaches are being implemented in a South-African context. As such, this confirms the relevance and importance of balancing systemic approaches with the human aspect to ensure that the safety improvements made are meaningful and add value to operations.

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APPENDIX A: INFORMED CONSENT FORM

NWU Business School
North-West University
Private Bag x6001
Potchefstroom, 2520

http://commerce.nwu.ac.za/business-school

DEAR PARTICIPANT

INFORMED CONSENT FORM

You are invited to participate in a research study that forms part of a Master of Business Administration (MBA) degree. Please take some time to read the information presented here, which will explain the details of this study. Please ask the researcher or person explaining the research to you any questions about any part of this study you do not fully understand. You must be delighted that you know this research and how you might be involved. Also, your participation is entirely voluntary, and you are free to say no to participating, this will not affect you negatively in any way whatsoever. You can also withdraw from the study at any point, even if you agree to participate now.

This study has been approved by the NWU Economic and Management Sciences Research Ethics Committee (EMS-REC). It will be conducted according to the ethical guidelines and principles of the North-West University and other international ethical guidelines applicable to this study.

Title of the project: Exploring the Systemic Interventions on the Safety Performance of Gold Mines in Gauteng

Institution: NWU Business School

Ethics Reference Number: NWU-00707-25-A4

Names and contact details of project staff

	Supervisor	Researcher
Title, name & surname	Dr. Banji Rildwan Olaleye	Mr. Michael Hopwood
Function in Project	Academic research supervisor	Researcher
Email	banji.olaar@gmail.com	20358725@mynwu.ac.za

What is this research study all about?

This study aims to describe the influence of systemic interventions on the operating and safety performance of the Gauteng gold mine. Furthermore, prominent challenges related to employee safety would be identified, and systemic interventions to be implemented during mining operations would be explored. A framework for overall safety performance would also be developed.

What will be expected of you?

You will be expected to:

- participate in a 45 to 60-minute face-to-face or virtual interview via Zoom or Microsoft Teams
- Interviews will be recorded (with consent) for accuracy and transcribed for analysis.
- Respond to the questions openly and honestly.
- Inform the supervisor should you feel or experience any discomfort or distress during the research process and inform the supervisor if you sometimes feel the need to terminate your involvement in the research process. You can terminate your participation before, during, and after the research process.

Participation in the study

- Participation in the study is voluntary

- Participants may withdraw from the study at any time. The researcher can be contacted at 20358725@mynwu.ac.za at any time to inform of any participant withdrawal. Data that has been collected about this individual will then be destroyed within 48 hours.

Will you gain anything from taking part in this research?

This study is self-funded and does not provide participants with direct financial or personal benefits. However, your participation will contribute to a deeper academic understanding of developing, implementing, and adapting systemic interventions and exploring influential factors that enhance safety performance and operational efficiency within Mines in Gauteng.

Are there risks involved in participating in this research, and how will they be addressed?

No physical risks are involved, but potential psychological risks may arise from safety incidents. Additionally, discussing safety incidents might cause distress. Participants may pause or withdraw at any time. Counselling services will be provided upon request.

As your input may contain sensitive information, the following ethical safeguards will be implemented:

- Your identity will be protected through anonymization.
- All personal data will be treated as strictly confidential.
- The research will be conducted in accordance with the Protection of Personal Information Act (POPIA), Act No. 4 of 2013, ensuring lawful and secure handling of your data.
- Your responses will be safely secured in a password-protected cloud-based system.
- No interviews will be undertaken. This is an entirely online process.

Your Rights under POPIA

In accordance with the Protection of Personal Information Act (POPIA), Act No. 4 of 2013, you have the right to:

- Access your personal data held by the researcher.
- Request correction or deletion of your data at any time.
- Withdraw your consent and participation at any stage without negative consequences.
- Be informed about how your information will be stored, protected, and used.

How will your confidentiality be protected, and who will access your data?

- You will be assigned a unique participant ID.
- Interview responses will be captured and stored securely concerning this ID.
- No identifiable personal information (e.g., name, contact details) will be disclosed or published.
- Data will only be accessible to the researcher and the authorized supervisor and stored in a secure, password-protected computer-based system.
- The findings will be presented in aggregated form, and no raw data will be published or shared with external parties.
- All research data will be retained for five years, per NWU and POPIA regulations, and then permanently deleted or destroyed.

What will happen with the research findings?

The findings will be used exclusively for academic purposes to contribute to scholarly literature. No commercially sensitive or personally identifiable information will be used or disclosed. However, please note that the results may be published in academic journals and that the completed MBA study will be available in the NWU library for research purposes.

How will you access the study results?

- If you would like to receive a summary of the findings, a copy of the final research report will be sent to you via email upon request.

Will you receive payment or incur any costs for participation?

Participation is voluntary and unpaid. There are no costs involved except for the time you spend participating in the study.

Additional Information or Questions

- If you have questions, you may contact:
- Researcher: Michael Hopwood | Email: 20358725@mynwu.ac.za
- Supervisor: Dr. Banji Rildwan Olaleye | Email: banji.olaar@gmail.com
- You will receive a copy of this form for your records.

Your responses are anonymous, and no personally identifiable data will be collected.

DECLARATION

Declaration by participant

By selecting the option below, I agree to take part in the research study titled: *Exploring the Systemic Interventions on the Safety Performance of Gold Mines in Gauteng.*

1. I confirm that I have read the information sheet for the above study. I have had the opportunity to consider the information, ask questions, and have these answered satisfactorily.

2. I understand that as I have completed the study anonymously it will not be possible to remove any information I have provided, as you will not be able to identify me in any way.

3. I understand that individuals from the University may review anonymous research data collected during the study to ensure that it is conducted appropriately.

4. I agree that my anonymous information can be shared with individuals from the abovementioned project team.

I agree to take part in the above study

Yes	No
1	2

Consent Statement:

Signing below confirms that you understand the study and agree to participate.

Signature: _____

Name: _____

Date: _____

APPENDIX B: INTERVIEW SCHEDULE

Interview Schedule

Objective: To structure the interviews effectively, ensuring that all key themes are covered within the allocated time and that insights align with the study's purpose.

Duration: Approximately 45 to 60 minutes per interview

Location: Face to Face at a secure location or via Zoom/MSTeams and Recorded

Rationale for Selection

- The introduction of systemic interventions is known, providing an opportunity to explore before and after implementation
- The selected operation provides a setting where the introduction of the interventions can assist in safety performance
- The selected gold mine has historically experienced challenges related to safety performance, making it a valuable context for this study
- Geographical location – located in Gauteng.

Structure:

Introduction (5 minutes)

- Brief explanation of the research purpose and framework.

  Thank you for agreeing to participate in this research study. This study explores the systemic interventions that affect the safety performance of gold mines in Gauteng. By contributing to this study, your insights will play a crucial role in exploring how the systemic interventions have contributed to safety performance

  i) by identifying the significant challenges regarding the safety of employees during mining,
  ii) what the key systemic interventions are that have been adopted at the operation,
  iii) the key aspects of systemic interventions that should be considered to influence safety

iv) what adoptable framework can be inserted to improve safety performance.

This framework provides a structured approach to exploring systemic interventions on the safety performance of gold mines in Gauteng. It seeks to understand the influence of these interventions and provide guidance to institutions on how these interventions are identified and implemented, with an understanding of the key aspects of these systemic interventions. This then culminates in contributing to a framework that can address safety performance via these interventions in the future.

This interview is structured to address several key areas. To begin, it will focus on your experience of safety challenges, followed by questions relating to systemic interventions implemented and their effectiveness. It will conclude with your thoughts on the key aspects of an adoptable safety framework to improve overall safety performance. Your participation is entirely voluntary, and you may withdraw at any time without any consequences. Your responses will remain confidential, and the findings will be used solely for research.

- Obtain consent and clarify the structure of the interview.

Before we begin, I would like to explain how this interview will proceed and obtain your consent to participate.

This session is expected to last approximately 45 to 60 minutes. During this time, we will cover several key themes related to the systemic interventions on safety performance in Gauteng Gold Mines. These themes include safety challenges in the mining environment, systemic intervention for safety, the key aspects and effectiveness of these systemic interventions and the components of an adoptable framework that can be inserted to enact an overall improved safety performance.

Your participation is entirely voluntary. You may choose not to answer specific questions or withdraw from the interview at any time without any consequences. This session will be recorded with your consent to ensure your responses are

captured accurately. The recordings and transcripts will be securely stored, and your identity will remain confidential. The findings and any subsequent publications will include No personally identifiable information. Compliance with the POPIA act will be ensured.

The interview will begin with an introduction to your role and perspectives on systemic interventions. Then, we will explore the predefined themes through open-ended questions, allowing you to share your experiences, opinions, and suggestions. We will conclude the session with an opportunity for you to provide any additional insights.

If you have any questions or concerns about the process, please ask before proceeding. By continuing with this interview, you indicate your informed consent to participate, to have your responses recorded and transcribed, and to contribute to this critical research.

May we proceed with your consent?

Exploration of Key Themes (40 minutes)

- Identification of major challenges regarding the safety of employees during mining (10 minutes) /Questions 1–2.
- Revealing the systemic interventions implemented during mining operations (10 minutes) /Questions 3–4.
- Exploring the aspects of systemic interventions that affect the safety of mining operations (10 minutes) /Questions 5–7.
- The establishment of a framework for overall safety performance (10 minutes) /Questions 8–11.

Closing (5 minutes)

- Invite additional comments.

- Thank the participant and explain the next steps.

Thank you for taking the time to share your valuable insights and experiences. Your contribution is greatly appreciated and will play an essential role in exploring the systemic interventions that affect the safety performance of gold mines in Gauteng.

We will now transcribe and analyse the responses from this and other interviews to identify recurring themes and insights. These findings will help answer the research questions while providing valuable insight into the operation and industry.

Once the research is complete, a summary of key findings will be made available to interested participants.

Thank you for your valuable time and input.

OPEN-ENDED INTERVIEW SCHEDULE

Purpose: To explore the systemic interventions on the safety performance of Gold Mines in Gauteng

Section 1: Identification of major challenges associated with mining

1. In your experience, what are the most significant safety challenges mines face daily?
2. Can you share examples of safety incidents / near misses and their contributing factors?

Section 2: Systemic Interventions for Safety

3. What systemic interventions (i.e systems/processes/strategies) are currently in place to improve safety performance?
4. Can you describe any recent or notable interventions to improve safety performance?

Section 3: Effectiveness and influence of systemic interventions

5. In your experience, which systemic interventions have contributed most to safety performance?
6. Were there any challenges encountered during the implementation of these interventions?
7. Have they influenced other factors such as the safety culture or employee behaviour?

Section 4: Components of an adoptable framework

8. Based on your experience, what should an ideal safety framework include?
9. What gaps or limitations do you see in the current framework?
10. What would be the top priorities if you had to design a safety improvement plan?
11. Do you have any additional insights to add? Are there any other individuals you feel should be contacted to provide insight to the study?

APPENDIX C: APPROVAL TO CONDUCT STUDY

Private Bag X1290, Potchefstroom
South Africa 2520
Tel: 018 299-1111/2222
Fax: 018 299-4910
Web: http://www.nwu.ac.za
Senate Committee for Research Ethics
Tel: 018 299-484
Feziwe.Mseleni@nwu.ac.za

4 July 2025

ETHICS APPROVAL LETTER OF STUDY

Based on approval by the **North-West University Economic and Management Sciences Research Ethics Committee (EMS-REC)** on 4 July 2025 , the Economic and Management Sciences Research Ethics Committee hereby **approves** your study as indicated below. This implies that the North-West University Senate Committee for Research Ethics (NWU-REC) grants its permission that, provided the special conditions specified below are met and pending any other authorisation that may be necessary, the study may be initiated, using the ethics number below.

Study title:	Exploring the Systemic Interventions on the Safety Performance of Gold Mines in Gauteng		
Study leader/Supervisor (Principal investigator/Researcher:	Dr B.R. Olaleye	**University no.:**	55612989
Student:	M.J. Hopwood	**University no.:**	20358725

Ethics number: N W U - 0 0 7 0 7 - 2 5 - A 4

Institution | Study number | Year | Status

Status: S = Submission; R = Re-submission; P = Provisional authorisation; A = Authorisation

Application type:	Single study - Postgraduate research	**Risk level:**	Low/minimal risk
Commencement date:	7/4/25		
Expiry date:	7/4/26		

Approval of the study is initially provided for a year, after which continuation of the study is dependent on receipt and review of the annual (or as otherwise stipulated) monitoring report and the concomitant issuing of a letter of continuation.

Special in process conditions of the research for approval (if applicable):

None.

General conditions:

While this ethics approval is subject to all declarations, undertakings and agreements incorporated and signed in the application form, the following general terms and conditions will apply:

- *The study leader/supervisor (principal investigator)/researcher must report in the prescribed format to the EMS-REC:*
  - *annually (or as otherwise requested) on the monitoring of the study, whereby a letter of continuation will be provided, and upon completion of the study; and*
  - *without any delay in case of any adverse event or incident (or any matter that interrupts sound ethical principles) during the course of the study.*
- *The approval applies strictly to the proposal as stipulated in the application form. Should any amendments to the proposal be deemed necessary during the course of the study, the study leader/researcher must apply for approval of these amendments at the EMS-REC, prior to implementation. Should there be any deviations from the study proposal without the necessary approval of such amendments, the ethics approval is immediately and automatically forfeited.*
- *Annually a number of studies may be randomly selected for an external audit.*
- *The date of approval indicates the first date that the study may be started.*
- *In the interest of ethical responsibility, the NWU-SCRE and EMS-REC reserves the right to:*
  - *request access to any information or data at any time during the course or after completion of the study;*
  - *to ask further questions, seek additional information, require further modification or monitor the conduct of your research or the informed consent process;*
  - *withdraw or postpone approval if:*
    - *any unethical principles or practices of the study are revealed or suspected;*
    - *it becomes apparent that any relevant information was withheld from the EMS-REC or that information has been false or misrepresented;*
    - *submission of the annual (or otherwise stipulated) monitoring report, the required amendments, or reporting of adverse events or incidents was not done in a timely manner and accurately; and / or*
    - *new institutional rules, national legislation or international conventions deem it necessary.*
- *EMS-REC can be contacted for further information or any report templates through the secretariat. Botlenyana Maluleka (Botlenyana.Maluleka@nwu.ac.za/ +27 18 2852436) or the chair Prof Diana Viljoen-Bezuidenhout (Diana.Viljoen@nwu.ac.za / +27 16 9103403).*

The EMS-REC would like to remain at your service as scientist and researcher, and wishes you well with your study. Please do not hesitate to contact the EMS-REC or the NWU-SCRE for any further enquiries or requests for assistance.

Yours sincerely,

Prof Diana Viljoen-Bezuidenhout

Digitally signed by Prof Diana Viljoen-Bezuidenhout
Date: 2025.07.04 16:16:40 +02'00'

Prof Diana Viljoen-Bezuidenhout

Chairperson: NWU Economic and Management Sciences Research Ethics Committee

APPENDIX D: TURNITIN REPORT

20358725:MHopwood_20358725.docx

ORIGINALITY REPORT

10%	8%	6%	3%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

PRIMARY SOURCES

1	wiredspace.wits.ac.za Internet Source	1%
2	Submitted to North West University Student Paper	<1%
3	repository.nwu.ac.za Internet Source	<1%
4	core.ac.uk Internet Source	<1%
5	www.researchgate.net Internet Source	<1%
6	ltu.diva-portal.org Internet Source	<1%
7	repository.up.ac.za Internet Source	<1%
8	www.diva-portal.org Internet Source	<1%
9	www.safetylit.org Internet Source	<1%

APPENDIX E: LANGUAGE EDITING CERTIFICATE

827 Dr Albert Luthuli Drive

Unit 3

Mmabatho

Mafikeng

2735

05 November 2025

TO WHOM IT MAY CONCERN

LETTER OF EDITING

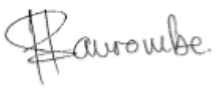
I, Hazvineyi A. Saurombe, confirm and certify that I have read, and language edited the dissertation titled: ***Exploring systemic interventions on the safety performance of gold mines in Gauteng***, by **M Hopwood**, Student Number: 20358725.

This dissertation was submitted in fulfilment of the requirements for the degree Master of Business Administration (MBA) at the North-West University.

M. Hopwood was supervised by Dr B.R. Olaleye.

The views and research procedures detailed and expressed in this dissertation remain those of the student.

Yours sincerely,



Dr H. A. Saurombe

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