The impact of behavioural transformation initiatives on occupational safety performance in the Company XYZ Mining environment in South Africa

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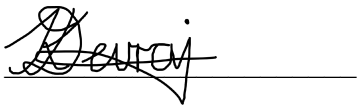
A Research Report submitted to the Faculty of Engineering and the Built Environment, University of the Witwatersrand, in fulfilment of the requirements for the degree of Master of Science in Engineering Management.

October 2021

DECLARATION

I declare that this research report is my own, unaided work. It is being submitted for the Degree of Master of Science in Engineering Management at the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination in any other University.



25/11/2021

Keegan Devraj **Date**

ABSTRACT

Occupational safety performance in the South African mining environment has long been a critical indicator of performance due to the moral, regulatory, operational, productivity and business impacts of safety incidents. Existing literature is aimed at improving safety performance, however minimal research has been conducted in the field of behaviour transformation within the mining industry.

This qualitative research study aimed to understand the main drivers of occupational safety performance at Company XYZ. This was achieved through an employee perception survey, a safety culture maturity assessment and incident investigation reports.

Survey results indicate high levels of safety perception and awareness, and improvement areas, such as safety training and hazard identification, were identified. The investigation reports revealed issues with reporting quality, incident learnings and multiple administrative control failures.

The overall outcome of this study is that the current programs aid in improving safety performance, however, there are several optimisation opportunities to further enable the organisation on its journey toward 'Zero Harm'.

KEY WORDS: Behaviour transformation, occupational safety, safety risk management, incident management, mining safety, 'Zero Harm'

DEDICATION

I dedicate this research report to my late grandmother, Mrs Muthamma Naidoo, and my mother, Mrs Yesavenie Rajpal, for their unconditional love, support and guidance. Without your constant encouragement and wisdom, none of my life achievements would have been possible.

I further dedicate this study to all our mining colleagues, who lost their lives in their lines of work. May the findings of this study aid in the journey toward Zero Harm.

ACKNOWLEDGEMENTS

I wish to express my heartfelt thanks and gratitude to the following people for their highly appreciated contributions to this study:

- Mrs Lorrainne Doherty, my research supervisor, for her unwavering support, wisdom and guidance and her commitment to ensuring I am working to my full potential
- Mr Kresan Pillay, my life partner, for his love and support during the many difficult hours in this process
- The Company XYZ: Mining employees, for their willingness to support the objectives of this study through their participation
- The leadership, HSE and learning teams at Company XYZ: Mining, for their support in arranging access to the required data, and for their willingness to share experience and knowledge throughout this study
- My managers and team mates, for allowing me the time to complete this research project timeously.

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LIST OF ACRONYMS

Acronym	Definition
FAC	First Aid Case
FY	Fiscal Year/Financial Year
GARR	Governance, assurance, regulatory and reporting
HSE	Health, Safety and Environment
HSI	High Severity Incidents
ILO	International Labour Organisation
KFA	Key Focus Area
KPI	Key Performance Index
KUE	Key Undesirable Event
LWDC	Lost Work Day Case
LWDCR	Lost Work Day Case Rate
MOC	Management of Change
MTC	Medical Treatment Case
OME	Operating Model Entity
PPE	Personal Protective Equipment
PTRA	Pre-Task Risk Assessment
RCA	Root Cause Analysis
RCR	Recordable Case Rate
ROH	Regional Operating Hub
RWDC	Restricted Work Day Case
SBU	Strategic Business Unit
SPSS	Statistical Product and Service Solutions
VBA	Visual Basic for Applications

GLOSSARY

Term	Definition
Behavioural transformation	The study and change of human behavioural factors such as ingrained habits
Bow-tie	A graphical risk management tool used to identify possible causes and consequences relating to the main event, as well as mitigating controls to prevent and correct this main risk event
Control	A measure put into place to minimize the probability or impact of a risk event
Hazard	A potential source of harm that may have adverse effects on personnel
HSI program	Company XYZ's internal suite of initiatives designed to minimise the occurrence of high severity incidents
Incident	An unplanned, unintended event that results in disruption
Key Undesirable Event	The focal point of the bow-tie that describes a single risk scenario that may materialise, due to several causes
Risk	The likelihood that harm may occur if personnel are exposed to a hazard
Root Cause	The primary fundamental reason for the occurrence of a problem incident

CHAPTER 1

1. INTRODUCTION

1.1. RESEARCH TITLE

The impact of behavioural transformation initiatives on occupational safety performance in the Company XYZ Mining environment in South Africa.

1.2. RESEARCH BACKGROUND AND CONTEXT

Company XYZ is a petrochemical company, based in South Africa. The business portfolio of Company XYZ includes a mining division, which is primarily responsible for coal mining as a feedstock to the petrochemical production facilities.

There has been an increasing trend in the number of safety, health, and environmental (HSE) related incidents in both the petrochemical and mining environments of Company XYZ over the past four financial years. The HSE fraternity, in the context of Company XYZ, includes process safety, occupational safety, occupational health, environment, security, and product stewardship (including product transportation). These have led to the development of the High Severity Incident (HSI) management program, which is the product of both internal best practice and external research and was intended to prevent both fatalities and high severity HSE incidents. The program has been implemented at a group level, with further implementation in all Regional Operating Hubs (ROH), Operating Model Entities (OME), and Strategic Business Units (SBU).

The HSI program was initially developed to incorporate five Key Focus Areas:(KFA):

1. Focus on Pre-Task Risk Assessments (PTRAs) and field verification of critical controls
2. Lifesaving rules

3. Institutionalising learning
4. Understand and influencing human behaviour
5. Process Safety Fundamentals

There are several behaviour-based controls contained within the five KFAs, with a specific focus on KFA 4.

In addition to the HSI program, Company XYZ employs the 'Bow-Tie' methodology, to manage the top 24 Key Undesirable Events (KUE) and relevant sub-events relating to HSE risk management across the group. The methodology is used to identify HSE risks, related causes and consequences and necessary preventative and corrective controls to mitigate the impact and probability of HSE risk events. The hierarchy of controls (Figure 1-1) illustrates the effectiveness of each level of hazard control. Incident root causes are identified through root cause analysis (RCA) and are indicative of control failure(s) or absence of controls. Root causes may be categorised as organisational, workplace, or gross violations of safety rules. The distribution of root causes, not currently analysed, indicates the required areas of focus in the organisation, to prevent recurrence of these incidents.

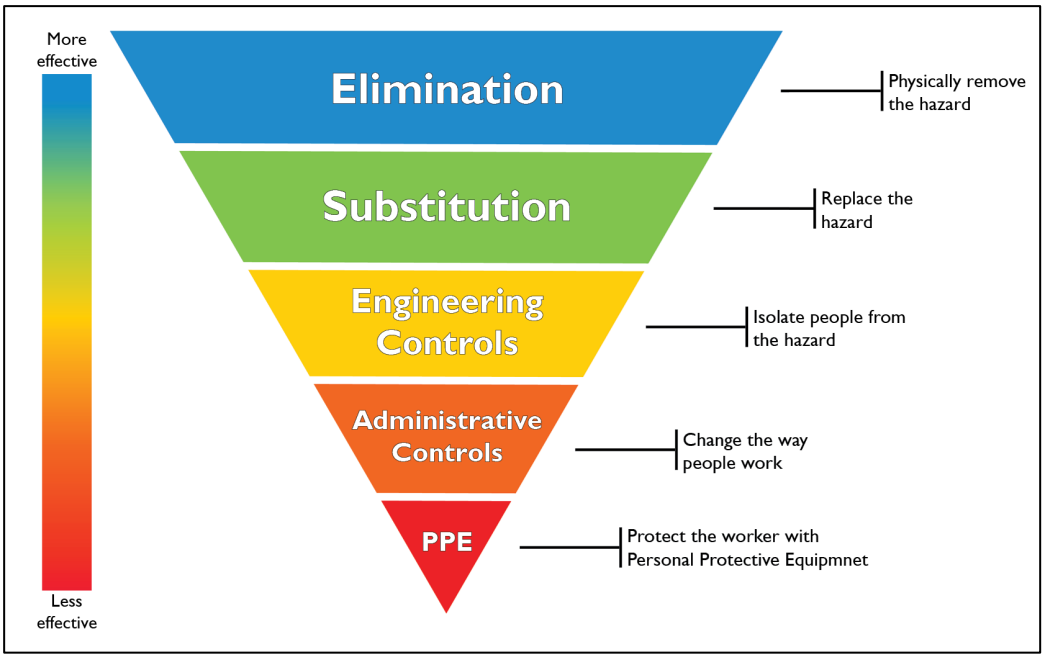


Figure 1-1: Hierarchy of Hazard Control (Zeiler, 2015)

The administrative type controls are related to work culture and behavioural impact on HSE performance. These controls are less effective than engineering controls, which seek to remove the behavioural/human aspect from HSE risk management. The relative proportion of engineering and administrative controls and associated control failures are not currently quantified and hence cannot be compared with the proportion of control failures identified in RCAs during the incident management process.

1.3. PROBLEM STATEMENT OR MOTIVATION

The impact of the implemented safety initiatives relating to behavioural risk management, specifically the HSI program, is not understood in its entirety. There is an increase in the number of HSE related incidents, specifically safety incidents, which warrants the investigation of the underlying causes of these incidents, as well as analysis of HSE incident data and the safety climate/culture in the business units that contribute to group statistics. Occupational safety represents the largest portion of high severity incidents recorded over the past four fiscal years, (FY) i.e. July – June 2016, 2017, 2018 and 2019, with Company XYZ: mining contributing to the most incidents (Figure 1-2). The mining business unit is of specific concern due to the high number of occupational safety-related HSI incidents as well as the increasing trend observed over the past four fiscal years. The HSI program's effect on HSE performance is not well studied and the effectiveness thereof needs to be established to optimise the program and the sub initiatives within the program to deliver optimal results as measured using group key performance indicators (KPI). The rationale for further capital investment in control optimisation and the efficiency of the currently implemented risk management processes has not been established.

The motivation behind this research is to improve group HSE performance by optimising current business processes and exploring additional/alternative programs to achieve ‘zero harm’ in the organisation.

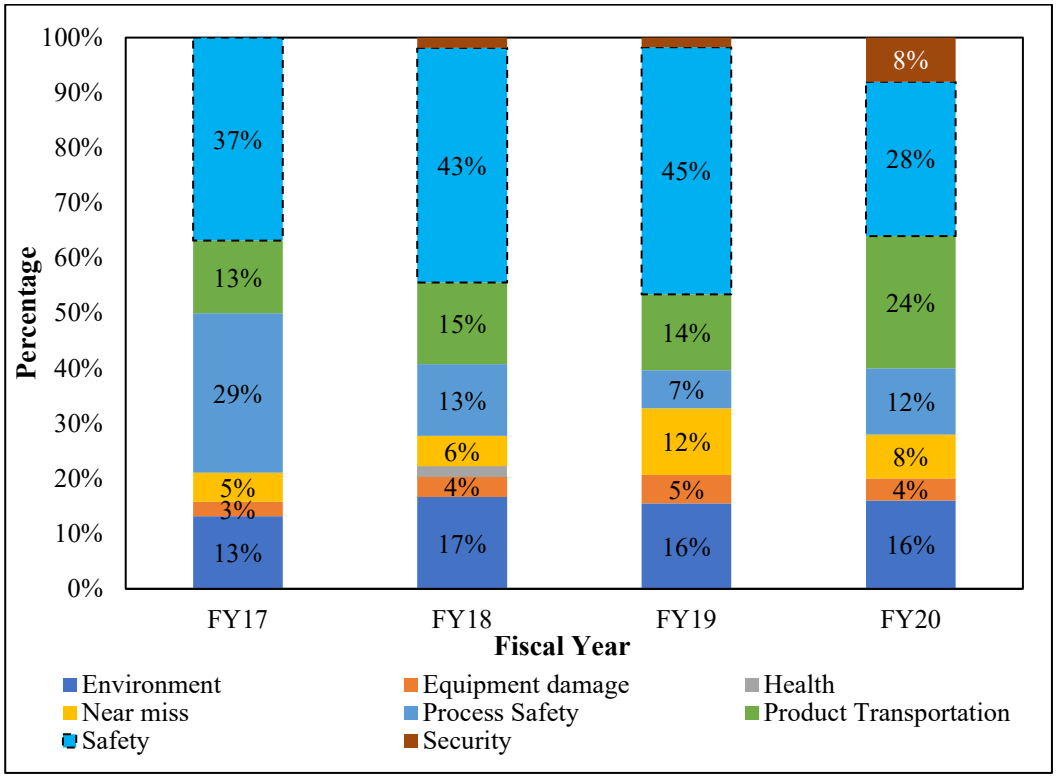


Figure 1-2 HSI statistics FY17- FY20

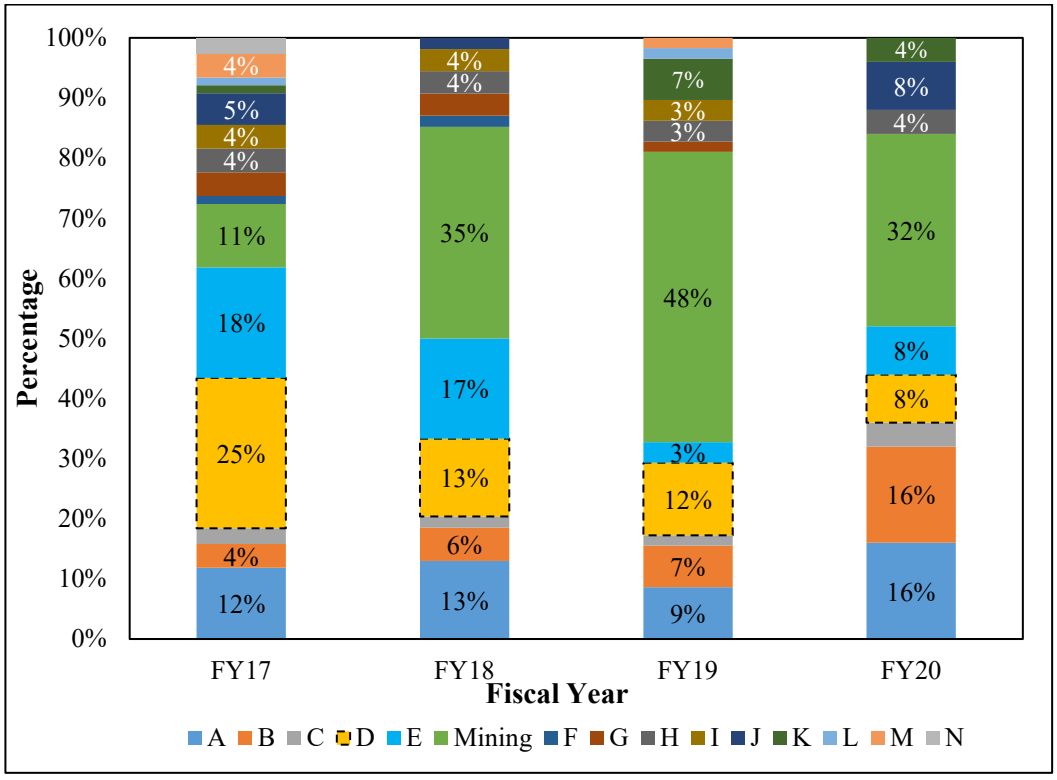


Figure 1-3: Safety HSI per business unit FY-17 - FY-20 (YTD)

1.4. RESEARCH QUESTIONS

The primary question this research aims to provide insight on is as follows:

- How are current behavioural transformative initiatives impacting the occupational safety performance in the mining business unit of Company XYZ in South Africa?

1.5. RESEARCH OBJECTIVES

The following research objectives are to be met to answer the critical research question:

a. Evaluate the changes in Company XYZ mining safety KPIs before and post-implementation of the HSI program and assess the efficacy of the program
b. Determine the optimal combination of engineering and administrative controls on bow-ties to effectively manage safety risks
c. Investigate and analyse the possible relationships between RCA root cause distributions and behaviour transformation initiative implementation to identify clusters of root causes and associated levels
d. Evaluate the safety maturity of the mining business unit and provide suitable recommendations to improve safety maturity

1.6. SUMMARY OF RESEARCH METHOD

The method employed in the study of "*The impact of behavioural transformation initiatives on the occupational safety performance of Company XYZ"* is presented below in Figure 1-4.

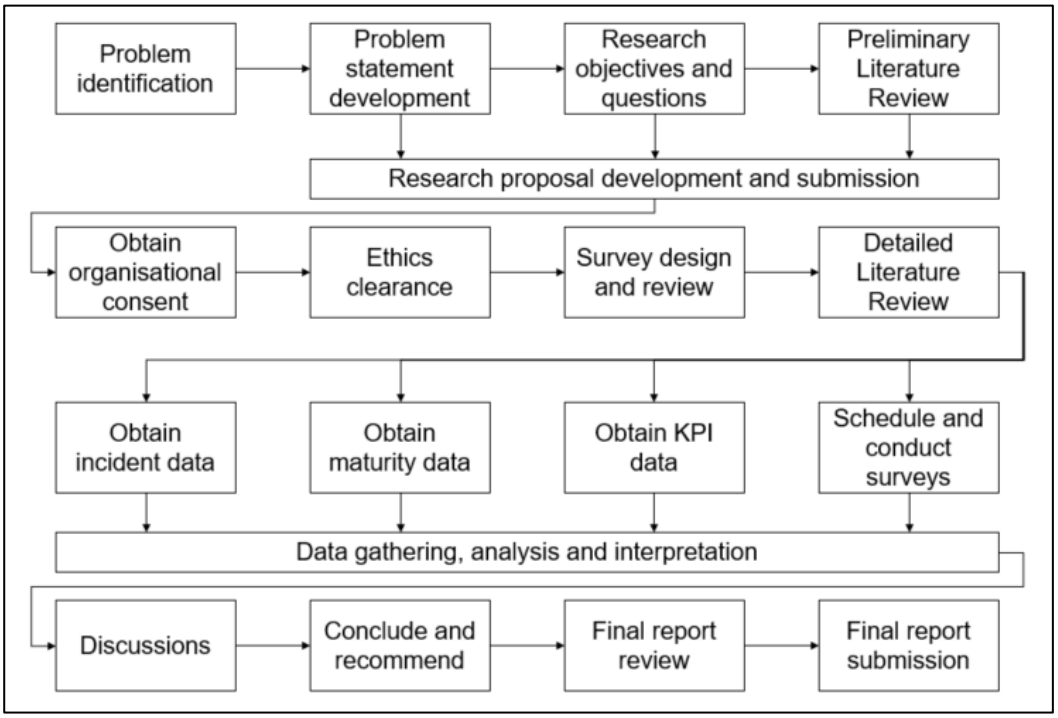


Figure 1-4: Research methodology

The research area was identified due to prior experience with Company XYZ's mining division and the associated safety performance. This together with a high-level review of the number of incidents and discussions with safety specialists and leaders at Company XYZ, and a preliminary literature review allowed for further refinement of the problem statement and the research objects and questions. The literature review was then expanded to gain further insight into similar research and to provide a steer for the direction of the research. A proposal was then prepared and submitted for review and final approval. An ethics clearance application was completed and approved after written consent was obtained from senior leadership at Company XYZ. It was discovered through various engagement sessions with relevant company stakeholders there are existing "Heartbeat" survey and maturity assessment results, however, a gap was identified in terms of assessing employee perceptions.

A survey was identified as the most suitable instrument to access employee safety perception and was developed after consultation with safety specialists within Company XYZ as well as through the use of existing literature. A five-point scale

was utilised to rate employee perceptions of 14 questions, split into 3 main categories viz. awareness, zero harm, and overall safety perception. The survey was administered in person, due to the lack of access to computers by the target group. In addition to the perception survey, data was gathered from previous surveys including the heartbeat survey, which was completed by the mining division in its entirety and the culture maturity assessment which was completed by leadership. Incident statistics and reports were obtained from the relevant representatives as part of the data gathering process. The data analysis segment of the research was conducted using Statistical Product and Service Solutions (SPSS) software as well as Microsoft Excel and Visual Basic for Applications (VBA). The results of the data analysis were discussed to conclude, and enable answering the postulated research questions. This was then followed by recommendations, using the results of this research, to ensure a sustainable improvement in the occupational safety performance at Company XYZ: Mining.

1.7. LIMITATIONS OR SCOPE OF RESEARCH

- The scope of this research project is limited to Company XYZ's mining division and does not include other business units within the group
- The research focuses on occupational safety, as a sub-category of HSE, and does not focus on occupational health, process safety, environment and other related categories
- The employee perception survey was administered to front-line employees and is limited to operators (including artisans) and shift supervisors
- All incident management data was processed as received by Company XYZ representatives
- The data gathering process was conducted at the Mpumalanga mining sites only and does not include any other mining operations the firm may have in South Africa or globally

1.8. OUTLINE OF CHAPTERS

An outline of the detail contained within the 8 chapters of this research report, including appendices and a list of referenced literature sources are presented in Table 1-1: Outline of Chapters

Table 1-1: Outline of Chapters

Chapter	Title	Description
Chapter 1	Introduction	Introduction of research title, research background and context as well as problem statement and motivation. This chapter also explores the research questions and objectives along with a summary of the research methodology and scope of research.
Chapter 2	Literature Review	A thematic review of literature relevant to the research topic and key concepts is presented in this chapter, including a discussion on the conceptual framework for this research.
Chapter 3	Research Methods	Chapter Three focuses on the research design, which is primarily a qualitative study and explores the sampling techniques with the associated data reliability and validity. Ethics considerations and anonymity are also addressed within this chapter.
Chapter 4	Data analysis and results	The statistical analysis of raw data used in this research as well as the final results are presented in Chapter Four.
Chapter 5	Discussion	The results obtained from the incident investigations, risk management tools and the survey is discussed in Chapter Five.
Chapter 6	Conclusions and Recommendations	Conclusions drawn from the results in conjunction with literature are discussed, to answer the research questions and objectives. Recommendations are put forward to improve Company XYZ: Mining occupational safety performance based on the findings of this research.
Chapter 7	Appendices	All additional raw data, research instruments and material not contained within the body of the research are presented in the appendices.

CHAPTER 2

2. LITERATURE REVIEW

2.2. INTRODUCTION

The following chapter presents a thematic literature review of theory relating to coal mining in the South African and Company XYZ context, an in-depth review of safety risk management and lastly, the incident management process. The literature review explores various factors related to the management of safety risks, in the mining environment. The conceptual framework is then presented to elaborate on the relationships between the various elements presented in this research.

2.3. COAL MINING

2.3.1. Coal mining in South Africa

Coal mining, in the South African context, began as early as 1864 in the Eastern Cape (Mccarthy and Pretorius, 2009). The discovery of gold in South Africa in the 1880s further exacerbated the country's need for coal to be utilised in electricity generation to support the developing infrastructure (Mccarthy and Pretorius, 2009). The 20th century saw the development of various mineral mining and processing industries, as well as the construction of the Free State and Mpumalanga petrochemical complexes. These developments together with urbanisation, population growth, and development of cities, led to an increase in demand for energy, both fuel, and electricity, which is primarily coal-based. South Africa currently produces around 258.9 million tons of coal per annum (2019 production) for national use and export to the international market (Minerals Council South Africa, 2020).

The costs associated with coal have been minimised historically due to the nature of coal as a secondary resource that was primarily used to support other industries (Munnik *et al.*, 2010). Low labour costs were achieved through the exploitation of

the black labour force. The black labour force, comprised largely of migrant workers, was employed by removing workers from their families and containing them in controlled compounds (Munnik *et al.*, 2010). The coal mining industry employed around 19% (86 919 employees) of the total mining labour force in the year 2018 (Coal Mining Matters, 2020).

There are three main methods employed in coal mining in South African, namely: bord/room and pillar, longwall, and opencast (Mccarthy and Pretorius, 2009). Each of the aforementioned techniques has inherent risks and exposure to these risks vary according to the types of machinery utilised and the number of personnel required to operate the machinery.

2.4. COMPANY XYZ: MINING

Company XYZ has operations in two geographical locations, Free State province and Mpumalanga. The Mpumalanga facility is considered one of the largest coal mining complexes (underground facilities) in the world. Company XYZ produces roughly 20% of South Africa's total coal output, to supply the Free State facility with coal for steam generation, the Mpumalanga facility with steam and electricity as well as feedstock for petrochemical processes.

Company XYZ utilises the bord and pillar mining method, using highly mechanised continuous miners, with a significant labour force involved in the process. The bord and pillar method, as illustrated in Figure 2-1 involves the creation of underground bords or tunnels, leaving supporting pillars to prevent roof collapse (Mccarthy and Pretorius, 2009).

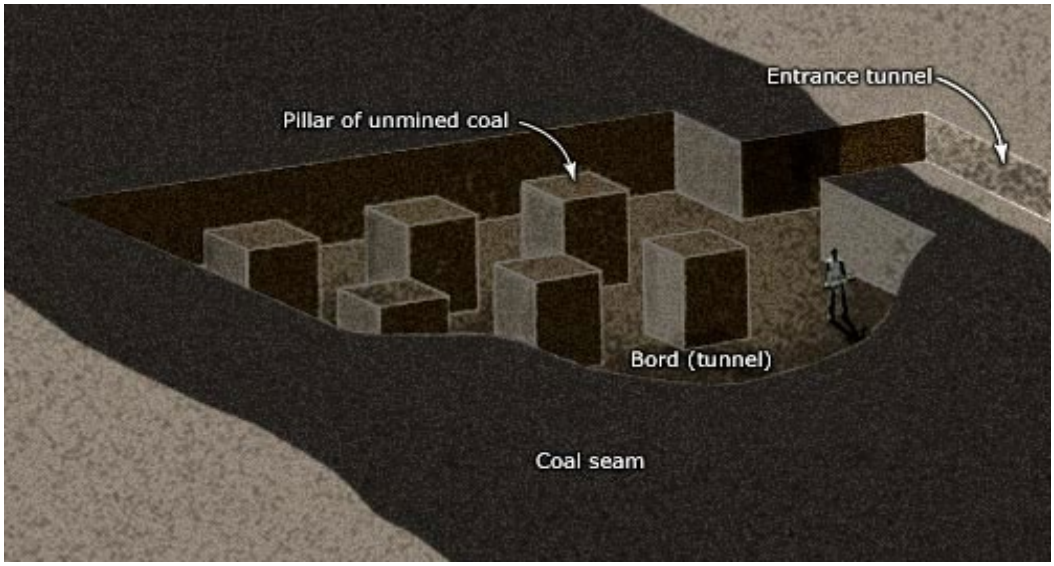


Figure 2-1: Bord and pillar mining technique (Alan and Jock, 2016)

2.5. OCCUPATIONAL SAFETY POLICY

The drive for corporate organisations to effectively manage health and safety-related risks arises from the International Labour Organisation (ILO) in conjunction with relevant country-specific legislation in the operating country (LaDou, 2003). These driving factors are purely from a regulatory perspective; however, the organisational culture and safety maturity may dictate the ability of the organisation to implement initiatives over and beyond the minimum legislative requirements.

According to LaDou (2003), approximately 10% of the population specifically in developing countries are covered by Occupational Health and Safety laws. This would require large corporates, with high performing safety cultures, to develop internal safety policies, in line with the organisation's performance aspirations.

Fernández-Muñiz, Montes-Peón and Vázquez-Ordás (2009) further emphasise the effects of occupational safety incidents on competitive advantage and productivity due to its impact on human capital. The development of safety policies that emphasise safety commitment and formalise the objectives and processes relating to safety, is critical when developing a safety management system to be rolled out to the organisation (Fernández-Muñiz, Montes-Peón and Vázquez-Ordás, 2009).

Company XYZ provides thought leadership to safety management, in a non-prescriptive manner, via the One HSE Excellence approach. This group-wide policy provides critical guidance on the definitions, scope and key indicators to be used to effectively manage safety risk at an operational level. In addition to the group policy, the mining division of Company XYZ has developed a rigorous safety procedure that is customised to the mining environment and its associated risks.

As part of continuous improvement initiatives, policies and procedures are reviewed periodically, to cater for changes in regulation, industry best practice and learnings from internal investigation processes.

2.6. Safety Risk Management

2.6.1. Safety in coal mining

The Mine Health and Safety Act 29 of 1996 governs the occupational health and safety in the mining industry and was passed to "promote a culture of health and safety" and well as to enforce regulations relating to health and safety specifically within the mining industry, due to the specialised risk profile of this industry (Mine Health and Safety Council, 2018). Figure 2-2 illustrates the key initiatives from the Mine Health and Safety Council since the development of the act and its associated regulations:

Figure 2-2: Key Mining Safety Initiatives (Phakathi, 2018)

These initiatives are being implemented to curb the number of fatalities, injuries, and accidents occurring in the mining industry (Phakathi, 2018). The number of fatalities per mining commodity is presented in Figure 2-3.

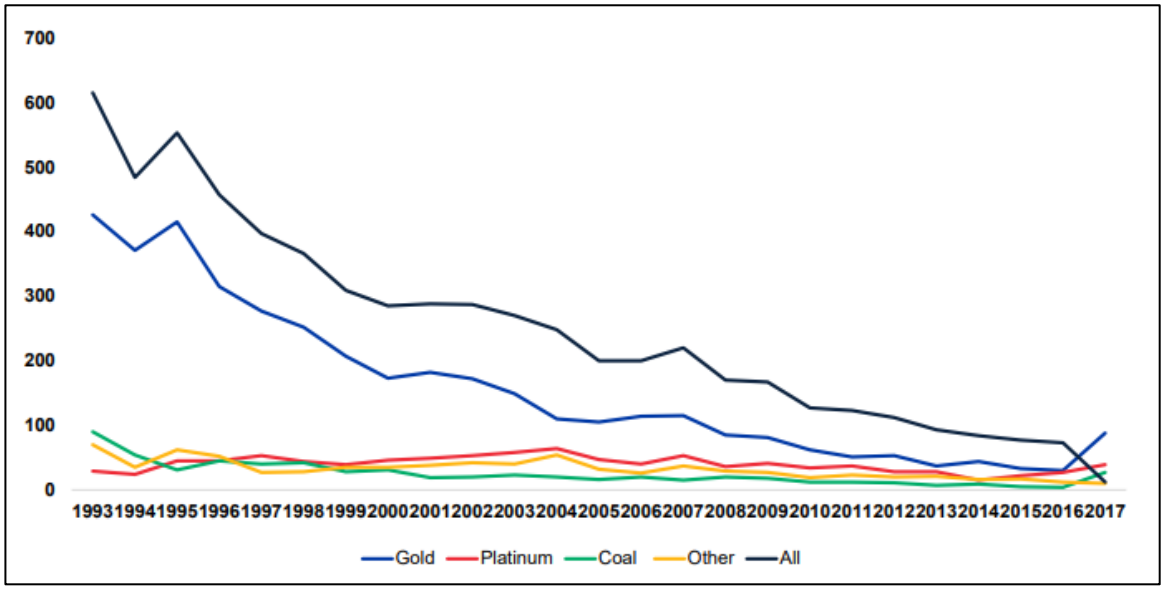


Figure 2-3: Mining related fatalities per commodity 1993 – 2017 (Phakathi, 2018)

The data presented in Figure 2-3 represents the total national (South African) mining fatalities, including fatalities arising from mine accidents. The industry has shown a significant decline in the number of fatalities, however, there is room for improvement as the industry strives towards a goal of 'Zero Harm'.

The social and economic impacts of occupational health and safety incidents further drive the rationale to minimise the number of incidents (Hermanus, 2007). There are direct costs (compensation, damage to equipment/assets, production loss) and indirect costs (loss of income to dependants, loss of livelihood) associated with occupation health and safety incidents, and these accounted for a 1-3% of GDP cost in many countries according to Hermanus (2007). These costs, aside from the regulatory moral obligation, are drivers for mining companies to put in place relevant processes and controls, including capital investment, to prevent safety incidents and the consequent harm to personnel and business.

2.6.2. Behavioural Transformation

Behavioural transformation or modification is imperative in managing safety, especially in areas where human behaviours have been linked to safety-related incidents (Ismail *et al.*, 2012). According to Cooper (1998), between 80% to 95% of accidents have behavioural aspects linked to the root cause. It is important to note these unsafe behaviours usually act together with 'accident causing pathogens', which result in undesired outcomes (Cooper, 1998). These 'pathogens' refer to faults/potential hazards that are inherent in design, systems, and procedures in the organisation, which may intermingle leading to the realisation of risk events (Cooper, 1998). It may, therefore, be beneficial to manage these intrinsic hazards by risk mitigation, substitution, or elimination, where possible, when managing behavioural aspects related to safety.

The goal of organisational behavioural transformation initiatives is to eliminate unsafe behaviours and simultaneously promote safe behaviour practices. This is in line with Heinrich's safety pyramid, Figure 2-4, which shows the hierarchy of safety incidents. Unsafe behaviour finds itself at the base of the pyramid, followed by near misses, minor, significant, and fatal incidents. Addressing unsafe behaviours/conditions is, therefore, the primary intervention required to ultimately prevent serious and fatal incidents.

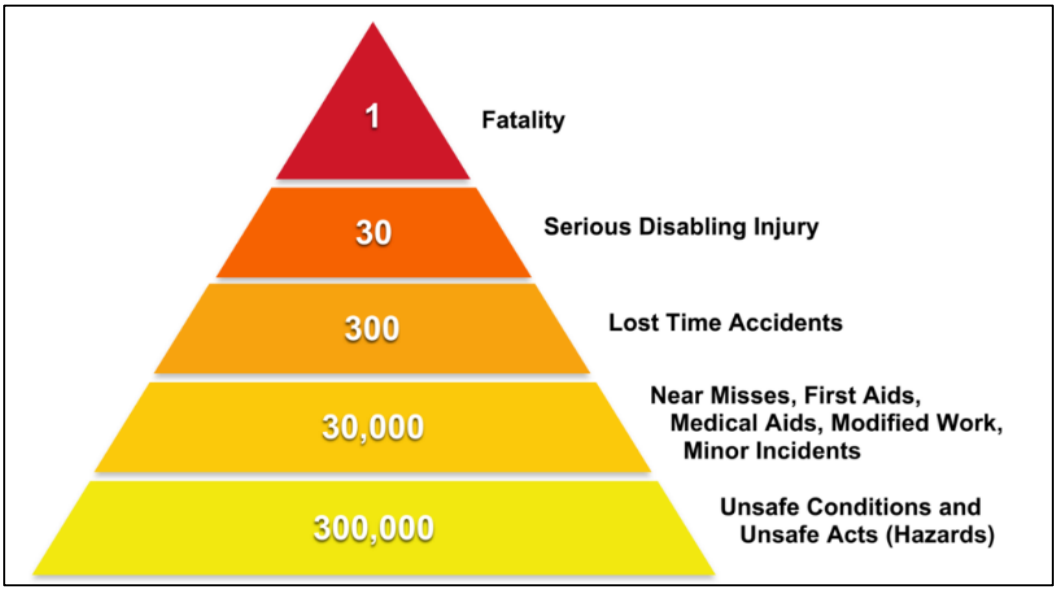


Figure 2-4: Safety pyramid/triangle (Kohler, 2019)

Unsafe behaviour is usually caused by complacency, rewarding unsafe acts (reinforcers), and delayed consequences (as depicted in the safety pyramid) (Cooper, 1998). Employees may engage in unsafe behaviour due to possible benefits, such as shorter time taken to complete tasks, increased/undisturbed production. Some employees may have never been involved in or been impacted by safety accidents despite performing tasks unsafely repeatedly over many years. Cooper (1998) discusses reinforcers and their impact on the organisation, as well as knock-on effects on the safety culture in the organisation in instances where management indirectly rewards unsafe acts by condoning such behaviour. Reinforcers in the workplace need to be identified and eliminated as part of behaviour transformation initiatives to ensure the efficacy of safety systems and policies.

Safety and production Key Performance Indicators (KPIs) may also act as reinforcers when applied inappropriately to business. Lagging safety indicators such as recordable case rates (RCR), incentivise good safety performance in the organisation and together with 'blame', dismissals, or any type of negative consequences relating to safety incidents, may result in employees not reporting incidents and/or near misses (Cooper, 1998).

Behaviour transformation not only relates to first-line employees but also to management and the organisation, as a whole. The ultimate goal is to create and maintain a mature safety climate in the organisation as opposed to management by exception, which is cyclical and does not provide a sustainable safety performance (Cooper, 1998).

2.6.3. Safety Culture

Culture may be defined as "The totality of socially transmitted behaviour patterns, arts, beliefs, institutions, and all other products of human work and thought characteristic of a community or population" (Ostrom, Wilhelmsen and Kalpan, 1993). Safety culture was formally conceptualised as a result of the Chernobyl Nuclear disaster that occurred in 1986 (Boughaba, Hassane and Roukia, 2014). A good safety culture, however, is dynamic in its definition as organisational and environmental factors influence its relative meaning (Ostrom, Wilhelmsen and Kalpan, 1993). Schulman (2020) notes similarities in behaviours, attitudes, and values of individuals in various organisations that are associated with good safety performance, which may be an indication of good safety culture. These organisations value safety above all other indicators of performance to the extent that operations are shut down when their definitions of tolerable risk levels are exceeded (Schulman, 2020). Ostrom, Wilhelmsen and Kalpan (1993) further identify the following characteristics that are portrayed by organisations with a good safety culture:

- Employees are vigilant and seek assistance when presented with change and unfamiliar situations which may present new hazards
- The organisation provides reward systems for employees to identify hazards and report unsafe environments or behaviour
- Safety is an organisational effort and is not dictated in a hierarchal manner
- The organisation is continuously gathering information and evolving based on learnings gathered both internally and externally

2.6.4. Safety Culture Maturity

Safety culture lends itself to assessments of maturity within organisations to identify the realm or region in which the organisation operates. Various models were developed to suit the individuality of organisations.

According to Goncalves, Kanegae and Leite (2012), an organisation's cultural maturity may be a significant hurdle in the adoption of new safety and risk management systems. To accurately develop and implement new systems and procedures, the safety culture maturity level of the organisation needs to be determined. The proposed system needs to be tailored according to the maturity level of the organisation to be successfully implemented.

Organisational safety culture maturity is categorised into three main phases: Founding and Early Growth, Midlife, and Maturity/Decline according to Schein (2004). The source and relative strength of the safety culture of each of the phases in the cultural evolution vary as follows:

- Founding and Early Growth: Relatively weak culture dictated by founders/initial leadership
- Midlife: Culture dictates leadership and the focus is on socialising the culture throughout the organisation
- Maturity/Decline: Organisational assumptions have developed due to long term success which results in a relatively strong existing culture

Fleming (2001) proposes a five-level maturity model, specifically for use in the oil and gas industry, and is illustrated in Figure 2-5.

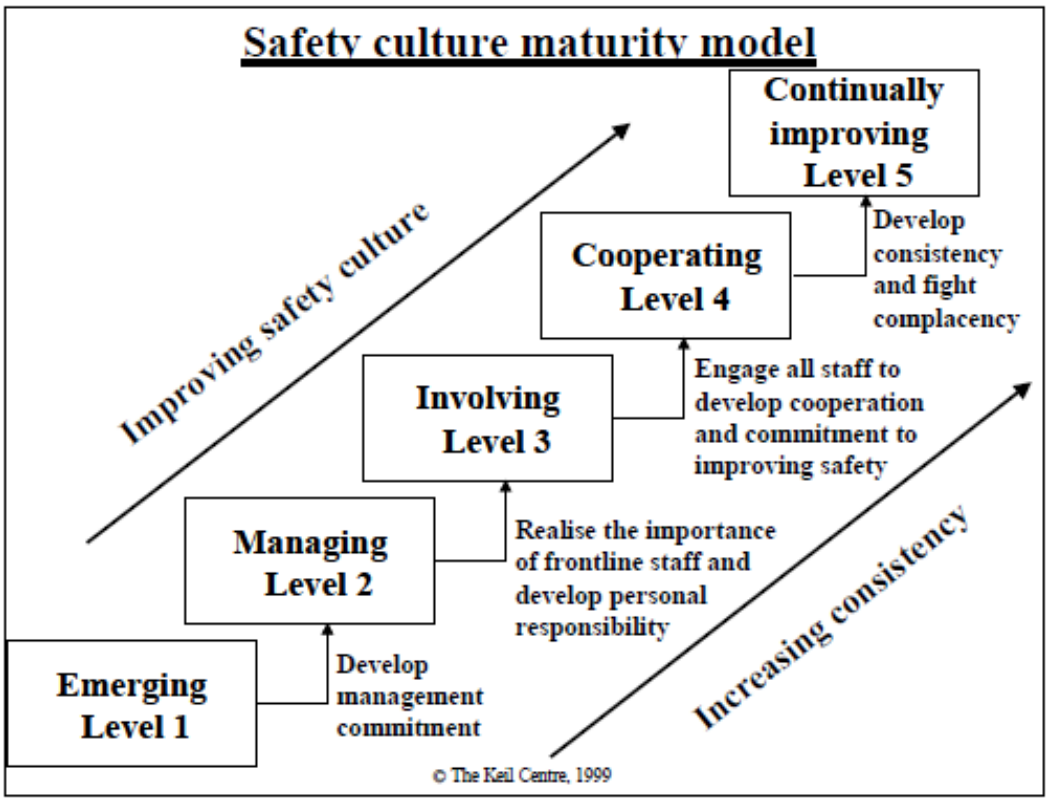


Figure 2-5: Five level safety culture maturity framework (Fleming, 2001)

Company XYZ has developed, at a group level, a customised four-level safety maturity assessment, for use throughout the organisation presented in Figure 2-6. The Company XYZ HSE procedure provides guidance and definitions of the four maturity levels and how and when to assess the safety maturity of the various business units. The results from the OME maturity assessments have not been aggregated to the organisation level and the group procedures are not formally informed by the organisation's safety maturity.

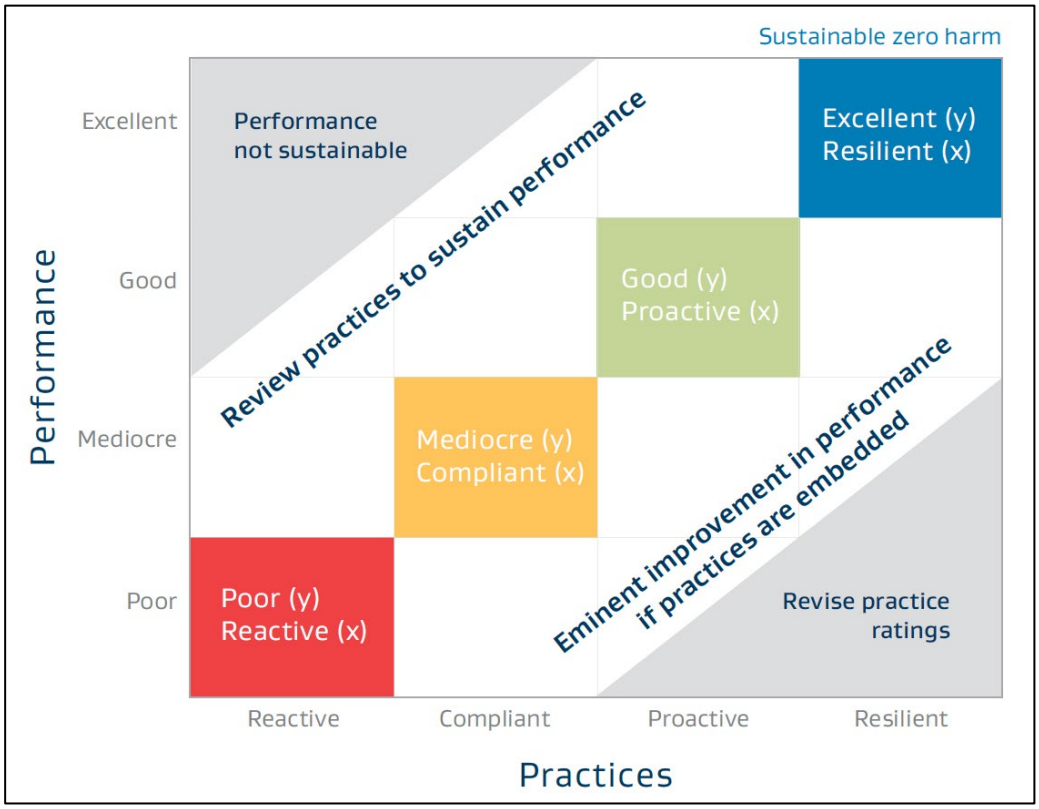


Figure 2-6: Company XYZ HSE maturity model

The roles and requirements from leadership vary significantly throughout the phases in attempts to making changes to the existing culture as employees with a varying appreciation for safety respond differently to safety initiatives employed using the top-down approach. It is therefore imperative to assess the maturity of the organisation as part of the iterative safety management process.

2.6.5. Safety Perception

In contrast to the organisational safety culture maturity, which is an indication of the long term culture that exists within Company XYZ, employee safety perception relates to the awareness, attitude and commitment of employees toward safety and risk. Pillay *et al.* (2010) postulate a safety metric, the gradient of reality, which may be used to access the efficacy of safety procedure implementation at the operator level. This notion is initially hypothesised by Borys (2009) as the difference in the perceived work done by management and the actual work done by the employees responsible for the execution of the work. This idea allows for quantification of the transmission of safety culture, implemented by leadership,

through the organisation to front line employees, who are most at risk from a safety perspective.

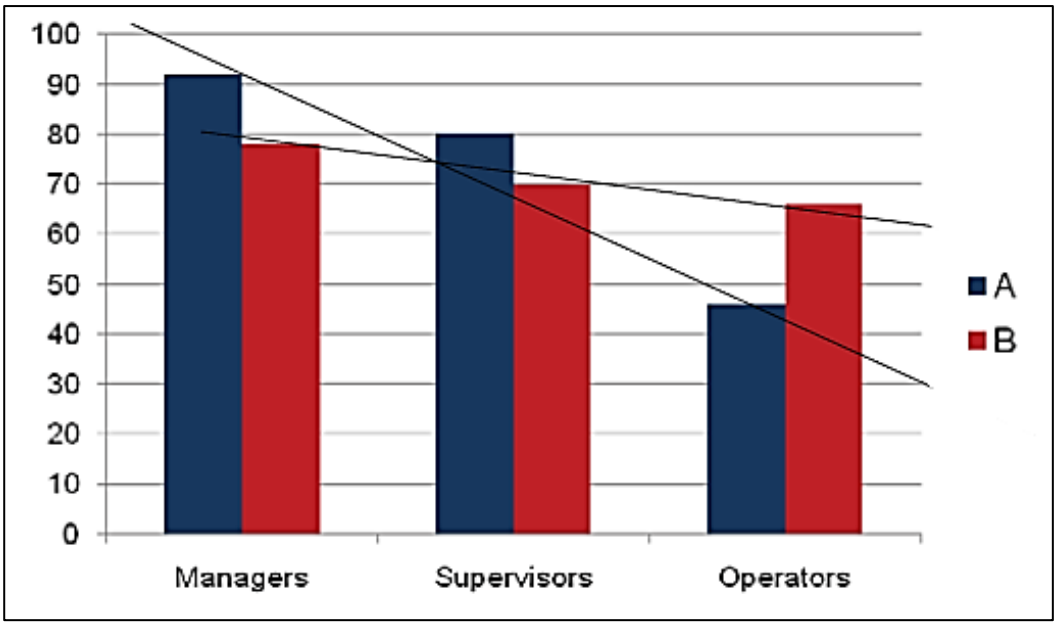


Figure 2-7: Reality Gradient of Safety (Pillay et al.,*2010)*

Figure 2-7 illustrates the concept of the reality gradient and alludes to various concerns at an operational level. A and B represent two hypothetical reality gradients, based on the two scenarios presented at each level of the organisation on the horizontal axis. Scenario B illustrates a steeper reality gradient than scenario A. The concerns include but are not restricted to, the tendency of employees to report incidents and/or unsafe acts or situations, the confidence employees have in HSE risk management systems and the general safety perception of employees. There may exist a natural gradient of reality due to socio-cultural barriers to the successful implementation of safety culture using the top-down approach, including the short-term safety climate in the organisation. The ultimate goal of leadership should be to ensure the gradient of reality is minimised thus ensuring a good safety culture is embedded throughout the company, especially within operations.

As an enabling mechanism to the reality gradient metric, the organisational safety culture, as determined at a leadership level, needs to be compared with employee safety perception. The perception of employees toward safety may be assessed using employee safety perception surveys. Important constructs to be considered

during the development of an employee perception survey include co-worker safety, commitment to safety programs, safe working enablement, and the general attitude toward working safely (Opoku, Kosi and Degraft-Arthur, 2020). In addition to these, the complexity of the surveys needs to be such that data is effectively extracted from a sample with relatively low literacy rates with significant barriers to communication due to language differences. The results of such a survey can be used in conjunction with safety culture maturity assessments, to identify possible areas of improvement to enhance safety performance.

2.6.6. Bow-tie Methodology

The bow-tie methodology is a tool that was developed in the 1970s, to effectively manage risk by identifying and implementing necessary control measures (Lewis and Smith, 2012). The bow-tie methodology is a graphical representation of the top event/key undesirable event (KUE), the associated hazard, possible direct causes, preventative controls, possible direct consequences, and corrective controls, as illustrated in Figure 2-8 (Khakzad, Khan and Amyotte, 2012).

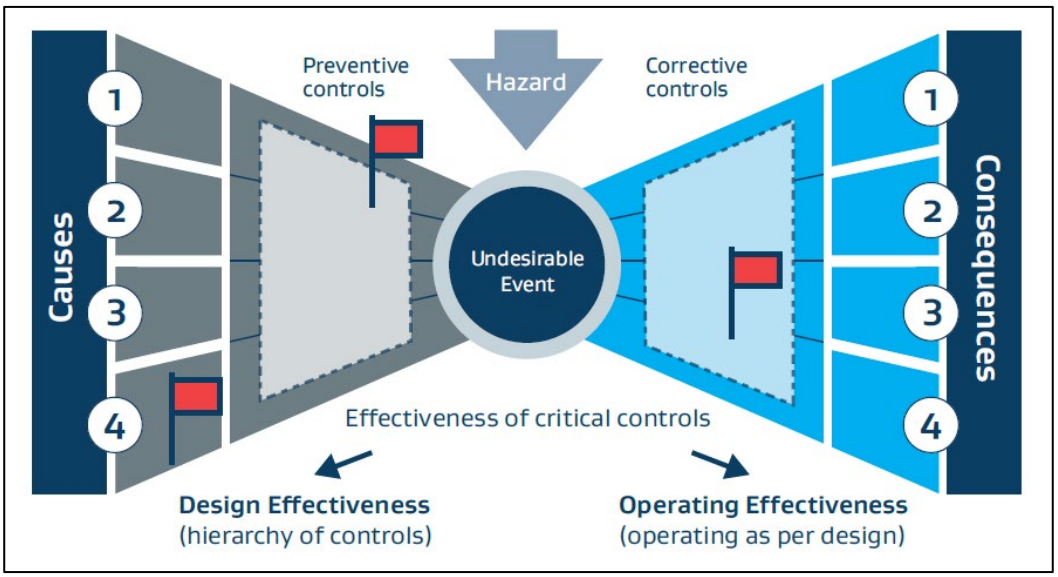
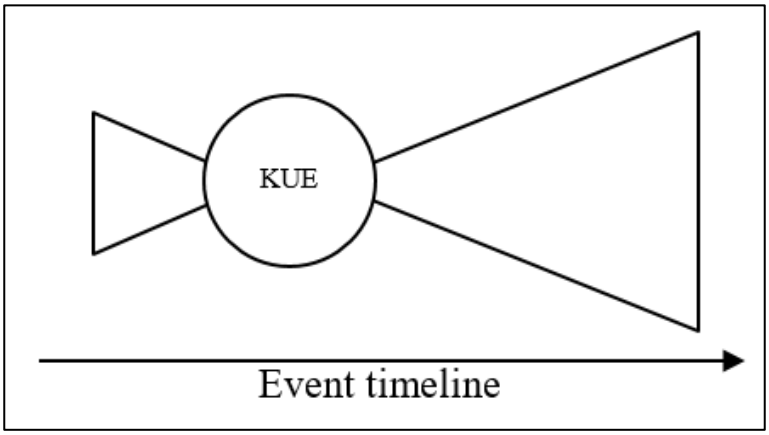


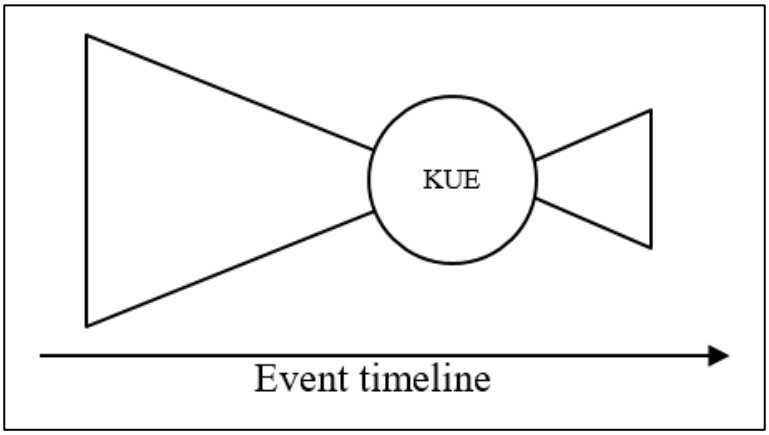
Figure 2-8: Bow-tie structure

The bow-tie methodology uses a systematic approach that requires the appropriate placement of the top risk event along the event timeline. The top event should be positioned optimally on the event timeline, to ensure effective mitigating actions

are put in place to prevent the KUE from materialising (Alizadeh and Moshashaei, 2015). Positioning the top event too early may result in the top event materialising with little control on the preventative side of the bow-tie. Similarly, positioning the top event toward the right of the even timeline may result in the realisation of consequences with inadequate corrective controls available for mitigation (Muniz *et al.*, 2018). The figures below illustrate examples of asymmetrical positional of the top event/KUE on the event timeline and the effects on causes and consequence sides of the bow-tie.



(a) Early top event



(b) Late top event

Figure 2-9: Asymmetric bow-tie diagrams

The left side (causes) constitutes a fault tree, identifying all plausible causes that may lead to the top event materialising, whilst the right side is indicative of an event tree, illustrating all plausible consequences that may occur should the top event be realised (Khakzad, Khan and Amyotte, 2012). Each causal line should include the

necessary controls or barriers required to prevent the causes from leading to the top event (preventative controls) and to prevent the top event from leading to the consequences (corrective controls). These range from administrative to engineering-type controls which vary in effectiveness. The implementation of engineering controls should be maximised, however, the trade-off with capital investment should be considered when deciding the ratio between control levels. Quantitative risk management may be utilised together with the bow-tie methodology to determine the probabilities of top events and consequences, together with the impacts, to determine the 'risk level' of each top event/KUE. These may then be used as guidelines for capital investment into engineering controls.

Proactive measures such as evaluation of control implementation and effectiveness as well as reactive measures such as prevalence mapping of control failures to identify possible focus areas may also be put in place with the implemented bow-tie methodology.

Company XYZ. uses the bow-tie methodology extensively in safety risk management at a group level and throughout the various OMEs. There are currently 24 HSE-related KUE categories at a group level, each with its associated sub-events/KUEs. These bow-ties are then customised as per OME applicability and are used as the primary method of HSE risk management.

2.7. KEY PERFORMANCE INDICATORS (KPIS)

The utilisation of Key Performance Indicators (KPIs) is integral to a firm's safety management system (Yousuf Blaou *et al.*, 2019). These indicators are characterised as being leading (proactive or predictive) or lagging (reactive). Zhou *et al.* (2018) note the importance of understanding the existence of inter relationships between leading and lagging indicators and hence the importance of including both leading and lagging indicators in an organisation's suite of performance indicators.

These KPIs enable management to set safety targets as a means to achieve continuous improvement goals and allow for identifying areas requiring attention where performance goals are not met (Manuele, 2009).

Company XYZ defines a KPI as a *"Defined and measurable metric used for evaluating performance, normally built into a KPI structure and broken down into lagging and leading indicators".* The following KPIs are recommended by Company XYZ's Group HSE function, for measuring occupational safety performance throughout the business:

Table 2-1: Company XYZ proposed occupational safety lagging indicators

Lagging indicators
• Number of fatalities
• Number of Lost Work Day Cases (LWDC)
• Recordable Case Rate (RCR)

Table 2-2: Company XYZ proposed occupational safety leading indicators

Leading Indicators
• Behaviour Based Safety barrier removal
• Incident action closure
• HSE training schedule compliance
• Inspection compliance
• KUE critical control compliance

The Recordable Case Rate (RCR) is calculated as follows (Goodrum and Gangwar, 2004):

Equation 2-1

$$RCR = \frac{Number\ of\ recordable\ cases \times 200\ 000}{Total\ employee\ hours\ for\ the\ year}$$

Goodrum and Gangwar (2004) define recordable cases as incidents or accidents when workers sustain injuries at the work place that require medical treatment from a doctor and is not treatable by first-aid.

Lost Work Day Cases (LWDC) are defined as cases in which workers are not able to perform their duties either partly or in full, due to the sustained injury and is included in the definition of recordable cases (Goodrum and Gangwar, 2004).

The use of LWDC as a lagging indicator is important to understand factors such as employee compliance to Personal Protective Equipment (PPE) requirements, the emergency preparedness and response capabilities such as first aid use and medical treatment (Coleman and Kerkering, 2007).

2.8. INCIDENT INVESTIGATION & ROOT CAUSE ANALYSIS (RCA)

The need for identifying a root cause stems from the identification of a problem (Andersen and Fagerhaug, 2003). In the context of mining safety risk management, these problems can be understood to refer to safety incidents. Andersen and Fagerhaug (2003) state there are several levels to the identified problem, of which the root cause is the "evil at the bottom" which is primarily responsible for the other levels identified within this framework as illustrated in Figure 2-10.

Root Cause Analysis (RCA) is an efficient and effective method of incident investigation, which is intended to facilitate the identification of causal factors and root causes during an incident, and to allow for recommendations to prevent incident recurrence (ABS Consulting *et al.*, 2014). The rationale for the RCA methodology is to ensure continuous improvement and to eliminate the occurrence of incidents as depicted in Figure 2-11.

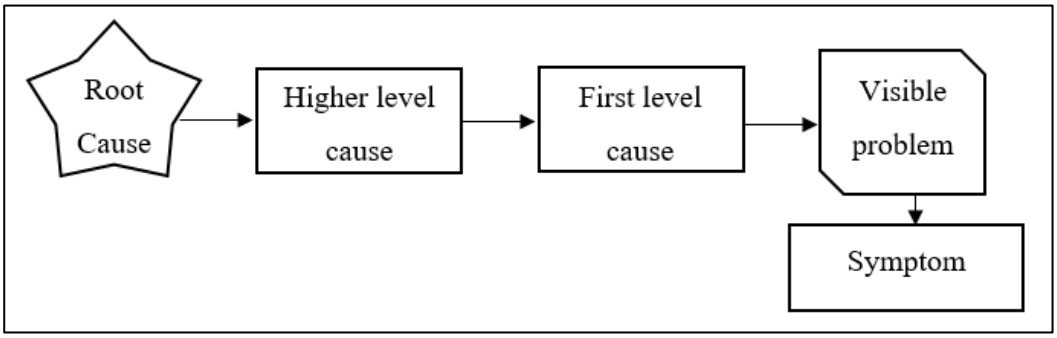


Figure 2-10: Root cause model (Andersen and Fagerhaug, 2003)

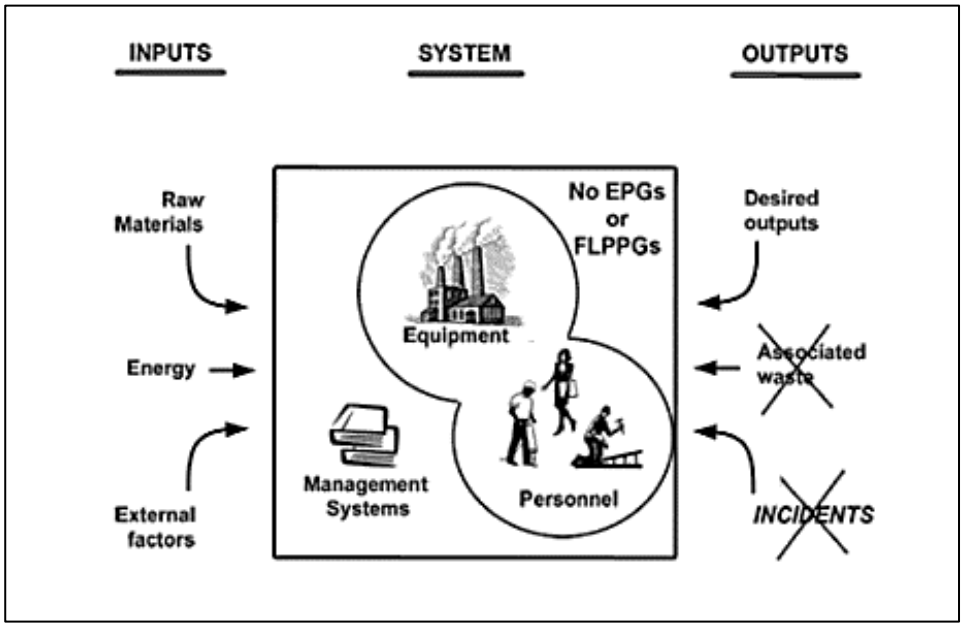


Figure 2-11: Idealised operations (ABS Consulting et al.*, 2014)*

The goals of the incident investigation process may vary from organisation to organisation, however, the underlying elements generally include ensuring safe, sustainable operations, by successfully identifying causes and implementing the required mitigating actions. This requires the correct, complete and timely completion of the RCA, by trained facilitators (Wu, Lipshutz and Pronovost, 2008).

The optimisation of an organisation's safety performance relies heavily on the RCA process and if this process is not conducted properly, the implemented corrective actions may not have the intended effect on performance.

2.9. CONCEPTUAL FRAMEWORK

The proposed conceptual framework was adapted from Ponnet *et al.*, (2018), and consists of three sections. The safety climate section will be assessed using the Company XYZ internal maturity assessment, the safety knowledge and motivation section will be assessed using the employee perception survey and the safety performance is currently assessed using existing Key Performance Indicators (KPI). This framework, presented in Figure 2-12, illustrates the relationships between the variables to be assessed within the scope of this research project.

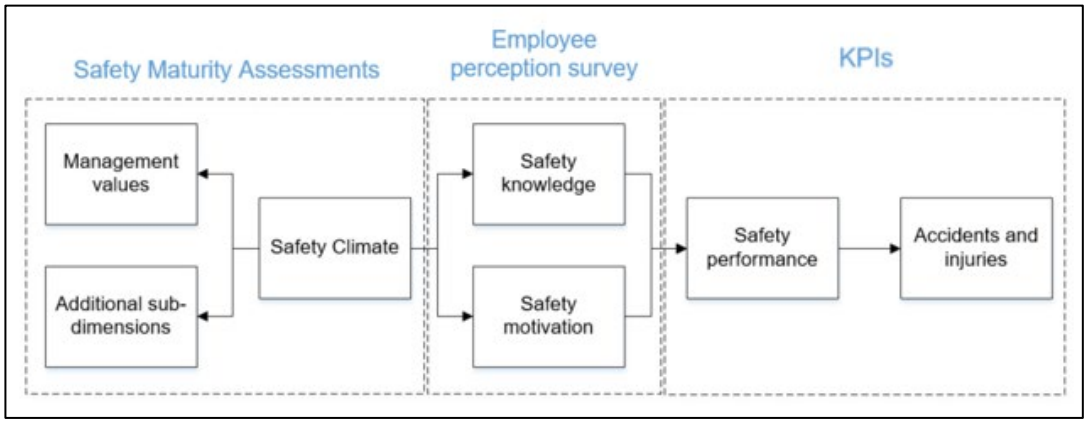


Figure 2-12: Safety culture conceptual framework (Ponnet *et al.*, 2018)

CHAPTER 3

3. RESEARCH METHODS

3.1. INTRODUCTION

The research methodology to be employed in conducting this research will be quantitative. A positivist, descriptive research philosophy will be employed as the data gathering instruments (survey and maturity assessment) are structured and will provide quantitative insight into employee and leadership perception of safety culture. Primary data will be gathered using the Company XYZ maturity assessment and an employee safety climate survey. This data is required to determine the safety culture maturity and to assess the front-line employee perception of the safety culture at Company XYZ: Mining. Existing data from Company XYZ: Mining incident RCA reports, bow-ties, and incident reports will be utilised to determine the efficacy of the existing safety risk management systems and to provide improvement recommendations to the HSI program to improve Company XYZ: Mining safety performance.

This chapter further elaborates on the research design, sampling method and instrumentation as well ethical considerations and required clearance.

3.2. RESEARCH DESIGN

The proposed research design of this study is both survey (primary data) and secondary data analysis. The employee safety perception survey comprised three segments to ascertain the ground-level safety perception (presented in Appendix E). A comparison of the survey results to the maturity assessment (secondary data) was necessary to assess the safety maturity level of Company XYZ: Mining and to determine whether the maturity level agrees with employee perceptions. Safety maturity culture assessments were completed by the middle to senior management teams within the Company XYZ: Mining business unit as per the Company XYZ HSE procedure guidelines. The safety perception survey was completed by operators, artisans and first-line supervisors within Company XYZ: Mining.

Surveys were conducted in person due to the nature of the work environment of Company XYZ: Mining employees. A target sample of 240 employees (operators and shift supervisors) was required to complete the employee perception survey as estimated using z-table scores as expanded on in the sample section.

The secondary data analysis segment of this research utilised safety maturity assessment data, RCA and incident investigation reports to investigate the change, if it exists, in the distribution of root causes before and after the implementation of the HSI behavioural transformation initiatives. The changes in existing safety KPIs were evaluated to assess the effectiveness of the HSI program. Group HSE and Company XYZ: Mining bow-ties were evaluated in terms of the hierarchy of controls and control failure prevalence from accident investigations to evaluate the effectiveness of the safety risk management processes that have been implemented. The ratio between administrative and engineering controls on the bow-ties was reviewed against control failure prevalence to investigate the need for increased engineering control implementation. Secondary data was obtained with the assistance of Company XYZ's Group Sustainability team.

3.3. SAMPLING

3.3.1. Population

The definition of the population to be considered in the research is critical in obtaining meaningful data and subsequently, meaningful results from the analysis of this data (Israel, 2018). Israel (2018) recommends identifying the population size based on the problem statement of the research.

The population considered in the employee perception survey was Company XYZ: Mining employees that are involved directly in mining activities and are therefore at the highest risk of being involved in mining-related safety incidents. These employees are expected to be most involved in occupational safety incidents, due to the inherent risk associated with their line of work.

The specific occupations included in the population are operators, artisans, foremen and supervisors. Company XYZ: Mining utilises service providers and temporary workers in addition to full-time employees, however, these employees will be excluded from the population size as the intent of the safety perception survey, is to determine long term safety perceptions within the organisation.

3.3.2. Sampling Technique

The necessity of using a sample to extrapolate results to the larger population is underpinned by resource constraints (i.e. time and monetary requirements to access the entire population) (Taherdoost, 2018). Acharya *et al.*, (2013) indicate the sample has to be chosen to be representative of the larger population to ensure the generalisability of the results. Taherdoost (2018) illustrates the sampling process steps undertaken during research in Figure 3-1.

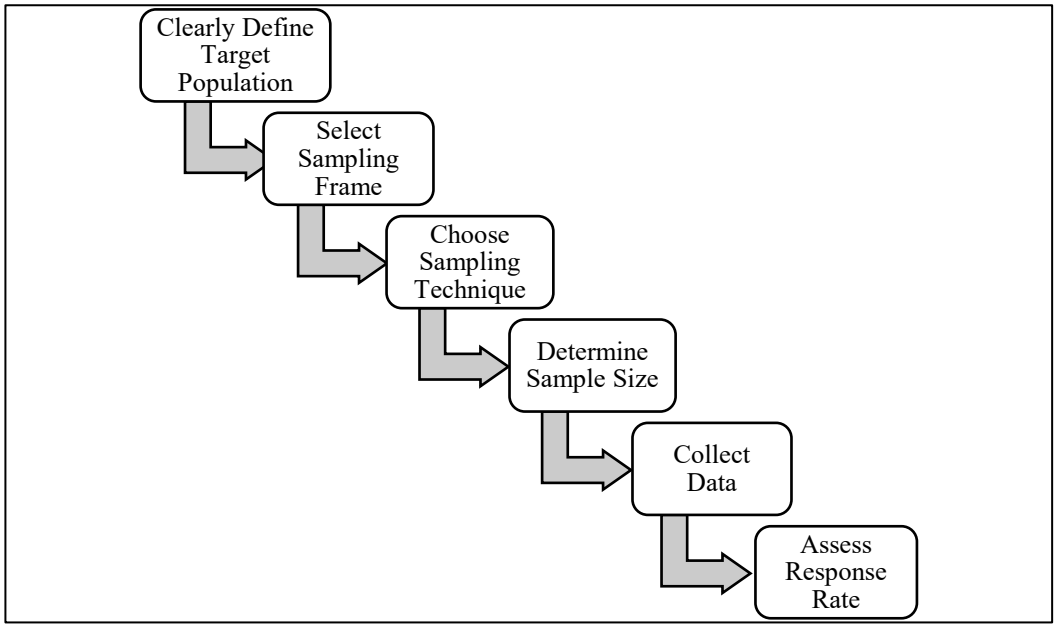


Figure 3-1: Sampling process steps (Taherdoost, 2018)

The sample frame selected for this research is Company XYZ: Mining employees at the learning centre undergoing annual safety training. This sample frame was selected based on the largest availability of operators, from different mine shafts, at a single point.

The sampling methods available are largely categorised as either probability or non-probability based (Acharya *et al.*, 2013). Probability sampling allows for every element present within the population to have an equal probability of being present with the sample (Etikan, 2017). Macinnis *et al.*, (2018) note that probability sampling methods, is in general, more accurate than non-probability sampling methods however Taherdoost, (2018) states that non-probability based sampling is typically associated with qualitative research as opposed to quantitative research.

Convenience sampling, a subset of non-probability sampling, involves the selection of survey participants based on availability (Mathieson, 2014). This type of sampling may introduce a degree of bias in the data obtained from surveys (Mathieson, 2014), however, in the context of this research, the ability to select specific participants/groups of participants is significantly more difficult due to the nature of work of the employees of Company XYZ's mining division.

A non-probability based, convenience sampling method was employed due to the nature of the selected population (operators and supervisors work underground to a large extent and have minimal/ no access to computers/email). Participation was voluntary and based on the availability of employees and permission from leadership at Company XYZ: Mining. Participants were, as far as reasonably possible, from various age groups with varying levels of work experience to minimise bias from age and complacency.

3.3.3. Sample Size

A minimum representative sample is required to minimise sampling errors and biases and is a function of the complexity of the population as opposed to a proportion of the population (Taherdoost, 2017). A suitable minimum sample size may be estimated using Cochran's equation, which is a function of the required level of confidence (typically 90%, 95% or 99%), the expected prevalence within the population (ranging from 0 to 1), the required precision and the population size (when available) (Bartlett II, Kotrlik and Higgins, 2001). The prevalence element is to be estimated by the researcher, however, in cases where the prevalence is not easily estimated, a factor of 0.5 is recommended for use as the expected proportion

(Naing, Winn and Rusli, 2006). In addition to Cochran's equation, Bartlett II, Kotrlik and Higgins (2001) proposes the use of Equation 3-2, to estimate the required sample size, when the population size, N, is known.

The minimum sample size required, calculated using Cochran's equation (5 % error margin, 90 % confidence interval, 1800 population size), is 239, hence a sample of 250 operators and shift supervisors were surveyed (Bartlett II, Kotrlik and Higgins, 2001). The selected number of participants has not been increased from the minimum, as a high rate of participation is expected due to the selected method of administrating the survey i.e., in person**.**

Equation 3-1

$$n_0 = \frac{Z^2 p(1-p)}{e^2}$$

Equation 3-2

$$n = \frac{n_0}{1 + \frac{(n_0 - 1)}{N}}$$

Where n_0 = sample size (infinite population)
n = sample size (known population)
e = desired level of precision
p = proportion of the population with the attribute
Z = critical value
N = population size

3.4. INSTRUMENTATION

There are various instruments available to enable the data gathering process, specific to qualitative, quantitative and mixed-method research (Zohrabi, 2013). The questionnaire or survey instrument is a primary method or instrument used in qualitative research and may include closed-ended, open-ended or a mixture of closed and open-ended questions to gather data from the proposed target audience of the study (Zohrabi, 2013). The closed-ended or structured questions provide

numerical data, such as with the use of a Likert scale, whilst the open-ended questions provide qualitative data (Zohrabi, 2013).

The Likert scale provides the means to understand human psychology, attitude and perception by providing the respondents with various options (five, seven and nine-point scales are common) (Joshi *et al.*, 2015). Albaum (1997) postulates there are two dimensions to measuring human attitude or perception; namely, the direction (either positive or negative) and the strength (how strongly positive or negative the disposition is). These elements are captured fairly accurately with a Likert scale instrument, as this type of instrument utilises a varying degree of options (strongly disagree, disagree, neutral, agree, strongly agree) to determine the respondents' perceptions/attitude towards the given statements/ideologies (Albaum, 1997).

The employee perception survey was designed with 14 closed-ended questions (using the Likert scale) and one open-ended question relating to additional suggestions/recommendation to improve safety performance divided into 3 categories (Awareness, Zero Harm and Safety Perception). This provides insight into the impact of Company XYZ: Mining's safety risk management program (HSI) as it filters through to ‘coal face’ level and the safety attitude of front line employees. The perception survey was designed to extract information on the safety climate as experienced by employees as well as to gain insight into the risk appetite of employees. Employees’ perceptions of the implemented safety programs and their effectiveness will also be gathered.

The Company XYZ safety culture maturity assessment was last completed in 2016 and indicates Company XYZ: Mining's maturity. The maturity level of Company XYZ’s mining division is illustrative of the degree to which practices (independent variable) impact safety performance (dependent variable). The results from the maturity assessment together with incident investigation reports and existing risk management tools (bow-ties) forms the secondary data input to this research project.

3.5. DATA COLLECTION AND ANALYSIS PROCEDURES

3.5.1. Data Collection

Primary data collection was undertaken using the employee safety perception surveys and was administered to employees (operators, artisans, foremen and supervisors) in person, at the annual safety training sessions. The surveys were completed in person due to technological limitations (access to laptops and internet/email) and to ensure maximum response rate.

The study rationale and objectives were verbally outlined before commencement with the survey and provision was made for linguistic barriers (primarily Afrikaans and isiZulu). The participants were assisted where required, to ensure accurate responses were obtained. Printed copies of the survey were handed to the respondents and a request was made to ensure the opinions provided in the survey were as honest as possible.

The letter of consent was administered before the commencement of the employee perception survey and was collected together with the surveys (Appendices A and B). Participation was entirely voluntary and participants were neither coerced nor rewarded to participate in this survey, to ensure no bias was introduced.

3.5.2. Data Analysis

Statistical analysis of both the survey and secondary data was performed from first principles and using formulae and functions available within the Microsoft Excel and Visual Basic for Applications (VBA) software packages as well as using the SPSS statistical analysis software. Secondary data was analysed using the comparative method, due to the positivistic nature of this research.

All input data were analysed critically, to draw conclusions and to meet the requirements presented with the research objectives section of Chapter One, and ultimately aims to answer the research question as well as to provide actionable recommendations to improve HSE performance at Company XYZ.

3.6. RELIABILITY AND VALIDITY

Reliability is defined as the extent of the consistency of data with time as its representability of the target population and the research instrument is considered reliable if the results are reproducible, under similar assumptions, in consecutive studies (Golfashani, 2003).

Validity concerns itself with the ability of the instrument to measure the intended parameters or phenomena (Tavakol and Dennick, 2011). Construct validity deals with the translation of a concept into an operating reality and face validity, a validity type within construct validity is a subjective analysis of how the concept has been operationalised (Drost, 2011).

The internal consistency or reliability of the primary data refers to the tendency of items within the instrument to measure the same thing and was estimated using Cronbach's alpha. The calculation of Cronbach's alpha requires an even number of survey questions; hence, this was considered during the development of the survey. Survey items with low relative correlation will be excluded to ensure internal consistency.

Face validity of the data was ensured by consultation with appropriate literature as well as internal reviews by Company XYZ HSE specialists.

3.7. ETHICAL ISSUES/CLEARANCE

Ethics clearance was required for the commencement of this research study due to the involvement of human subjects in the employee safety perception survey.

3.7.1. Risk exposure

The nature of this study is low to minimum risk, as per definitions provided in the ethics clearance application form and necessary ethics clearance will be applied for following relevant procedures.

3.7.2. Intellectual property and legal requirements

The HSE data and investigation reports utilised as secondary data contain sensitive, confidential information relating to Company XYZ and may have reputational and legal impacts if presented inappropriately or if data security requirements are not adhered to. Formal sign-off was obtained from senior leadership within the company to conduct this research project with the following mitigating actions in place to avoid undesired consequences:

- The organisation's name is not explicitly mentioned within the report and the report should refer to the organisation in any shape or form
- A copy of the report shall be provided to Company XYZ's legal representative and HSE leadership, before submission, for review to ensure anonymity is maintained
- Data will be normalised as far as reasonably possible, and percentages should be used instead of absolute values where practical

The permission letter submitted to and signed off by the Vice President: HSE at Company XYZ is presented in Appendix C (names excluded due to confidentiality requirements).

3.7.3. Anonymity, confidentiality and privacy of respondents

Confidentiality and anonymity were adhered to where necessary and provisions for such are to be made in the letter of consent and the participant information sheet which was completed by all subjects in the selected sample. Data that enables the identification of participants, such as name or position within the organisation was not collected as part of the survey results.

3.7.4. Plagiarism

All information/data obtained from external sources were formally cited and referenced in the research report and the research complies with the plagiarism policy of the University of the Witwatersrand.

3.7.5. Falsification and fabrication

All information presented in this research report is true and was not fabricated in any way.

In accordance with the aforementioned provisions, ethics clearance was obtained through the School Ethics committee (clearance protocol number MIAEC 110/20). Ethics clearance was approved unconditionally and is valid to the date of submission of this research report. The approved ethics clearance certificate is presented in Appendix D.

CHAPTER 4

4. DATA ANALYSIS AND RESULTS

4.1. INTRODUCTION

This chapter outlines the analysis of the data collected through the employee safety perception survey, the occupational safety incidents reports and the Company XYZ safety maturity assessment.

A statistical analysis of the survey response data (primary data), including checks for normality, which informed the statistical test methods employed and internal consistency are presented in this chapter.

The results from the incident reports and maturity assessments (secondary data) are also presented within this chapter, which forms the basis for the discussion of results, conclusions drawn and the recommendations put forward, to meet the research objectives and to answer the research question postulated in Chapter One.

4.2. EMPLOYEE PERCEPTION SURVEY: STATISTICAL ANALYSIS

The questions numbers and corresponding questions presented within the statistical analysis and results sections of the Employee Perception Survey are illustrated in Table 4-1: Employee Perception Survey questions.

Table 4-1: Employee Perception Survey questions

Number	Question
1	I am aware of my departmental safety procedure
2	I am informed of safety incidents and lessons learnt in a reasonable time
3	I am familiar with safety laws that apply to my line of work
4	I am regularly informed of safety hazards and safe work habits
5	I am able to act in the event of an incident
6	I believe zero harm is achievable
7	Safety is my highest priority when performing any task
8	I am mindful of my impact on workplace safety

9	I am equipped with everything I need to work safely
10	I believe safety is my responsibility
11	I feel comfortable performing my duties in a safe work environment
12	The safety of my colleagues' matter to me
13	I have been trained sufficiently to perform my job safely
14	Our current safety program is sufficient to address all my concerns

4.2.1. Normality tests

The statistical methods, used to analyse data, must be selected based on the characteristics of the data being analysed (Das and Imon, 2016). Tests for normality can be performed using descriptive statistics, analytically using the measures of kurtosis and skewness (Ahad *et al.*, 2011), or graphically using histograms, steam and leaf plots, box and whisker plots, normal percent-percent plots or normal quantile-quantile plots (Das and Imon, 2016).

Kurtosis is a measure of how 'peaked' or 'flat' data is and provides the ability to compare the obtained data to normally distributed (Gaussian distribution) data (DeCarlo, 1997). 'Leptokurtic' distribution refers to data with a positive kurtosis value and indicates the presence of 'narrow, tall' peaks, whilst 'platykurtic' distribution refers to 'flat' data as is characterised by a negative value of kurtosis (Ahad *et al.*, 2011).

Skewness is defined as the degree of asymmetry a dataset exhibits, concerning the mean, median and mode of the data (Li, Qin and Kar, 2010). A data set exhibiting perfect normal/Gaussian distribution will imply that the mean, median and mode of the data set are equal (Doane and Seward, 2011), and deviations from this condition are presented in Figure 4-1.

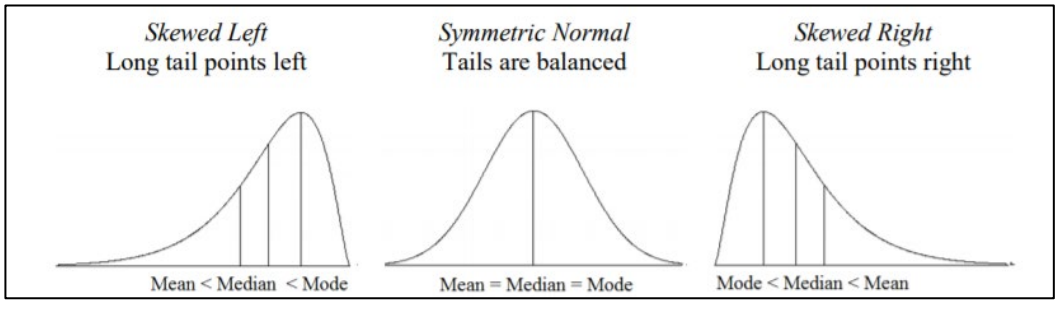


Figure 4-1: Skewness as a function of mean, median and mode (Doane and Seward, 2011)

Skewness and kurtosis values of zero, indicate the perfect normal distribution of data, however, a range of -1 – +1 is recommended for skewness and -3 – +3 for kurtosis to represent an approximately normal distribution (Bulmer, 2012):

Skewness and Kurtosis: Analytical method

The tests for normality (skewness and kurtosis) was performed using the SPSS software package and results are presented below:

Table 4-2: Skewness and kurtosis data obtained from SPSS

Question number	Kurtosis	Skewness
1	6,70	-1,98
2	4,31	-1,62
3	4,33	-1,66
4	5,11	-1,75
5	3,63	-1,54
6	5,58	-1,91
7	10,60	-2,60
8	7,78	-1,99
9	3,74	-1,51
10	13,52	-2,86
11	7,98	-2,43
12	7,16	-2,16
13	5,54	-1,86
14	2,84	-1,48

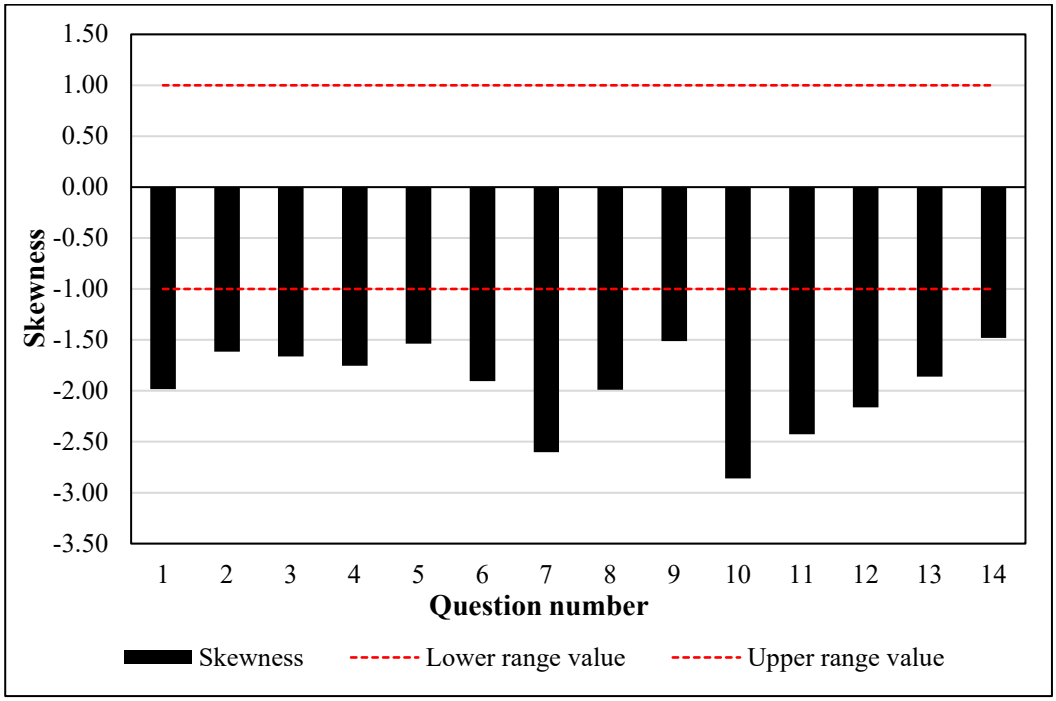


Figure 4-2: Skewness results for employee safety perception survey

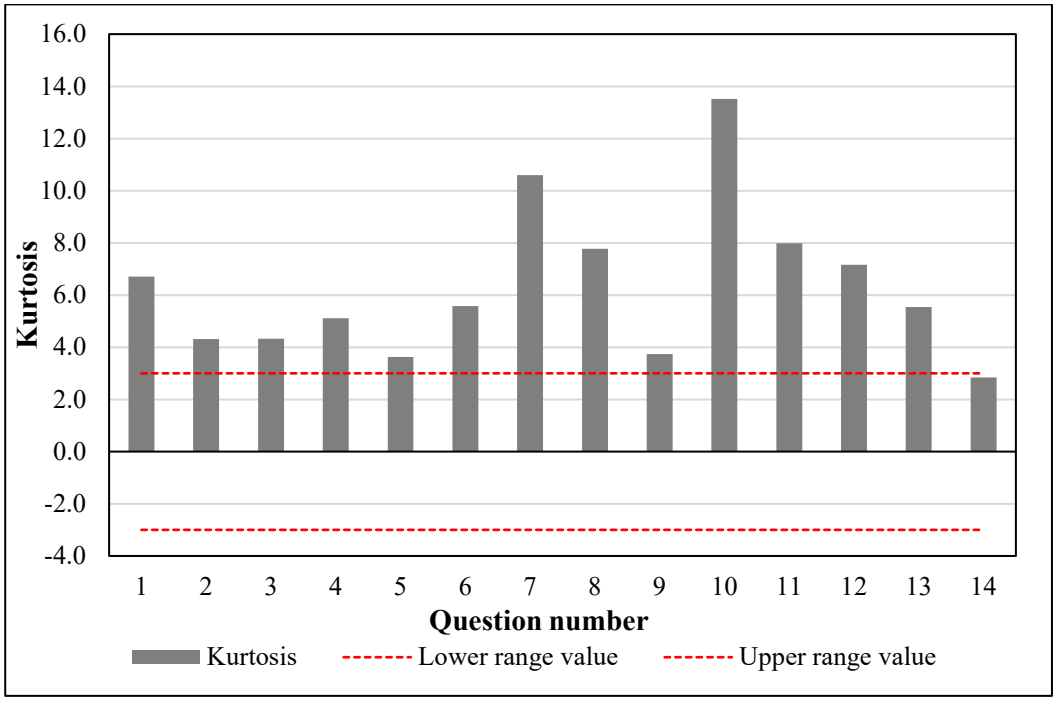


Figure 4-3: Kurtosis results for employee safety perception survey

The skewness and kurtosis data produced by SPSS both reside outside the prescribed bounds for normally distributed data (except kurtosis for question 14). All the questions' results have produced a positive value for kurtosis, indicating the

distribution of the data is leptokurtic, whilst the negative values for skewness indicate the data is negatively skewed (skewed left), suggesting a high density of data points toward the right (i.e. 5 – Strongly Agree). This infers the standard parametric tests for statistical analysis will not be appropriate for this data set, as these tests assume an approximately normal distribution. Instead, a non-parametric approach is necessary to accurately analyse the results of the employee safety perception data.

Skewness and Kurtosis: Graphical method

The following histograms were generated using the SPSS software package and can be used to visually determine the skewness and kurtosis characteristics of the employee safety perception survey results.

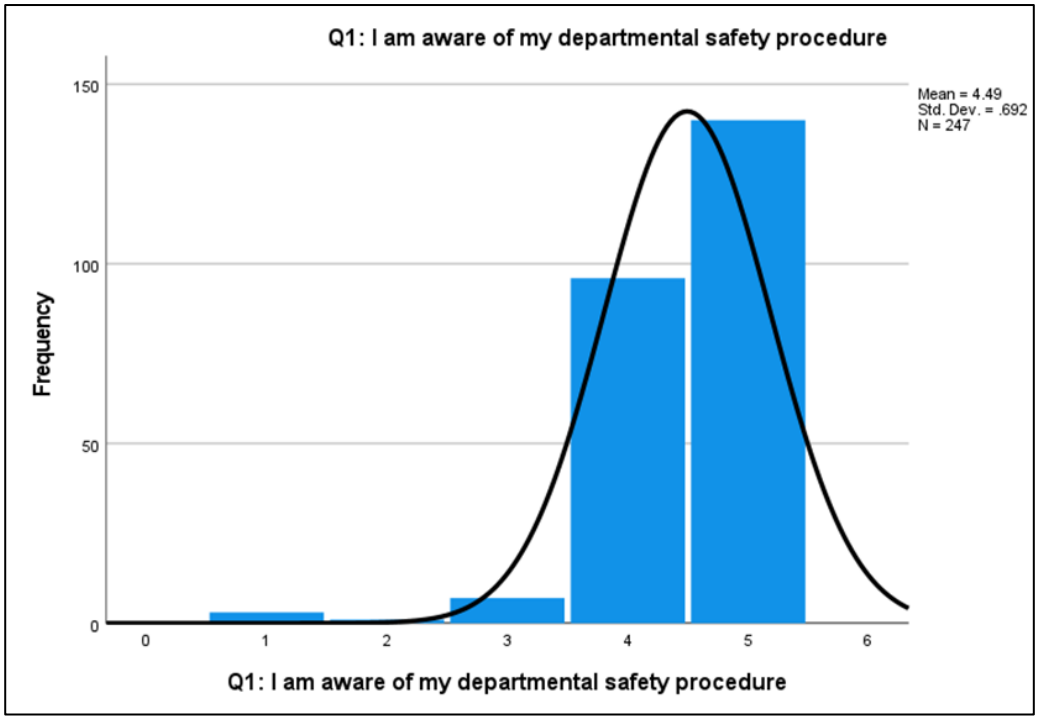


Figure 4-4: Histogram - Question 1

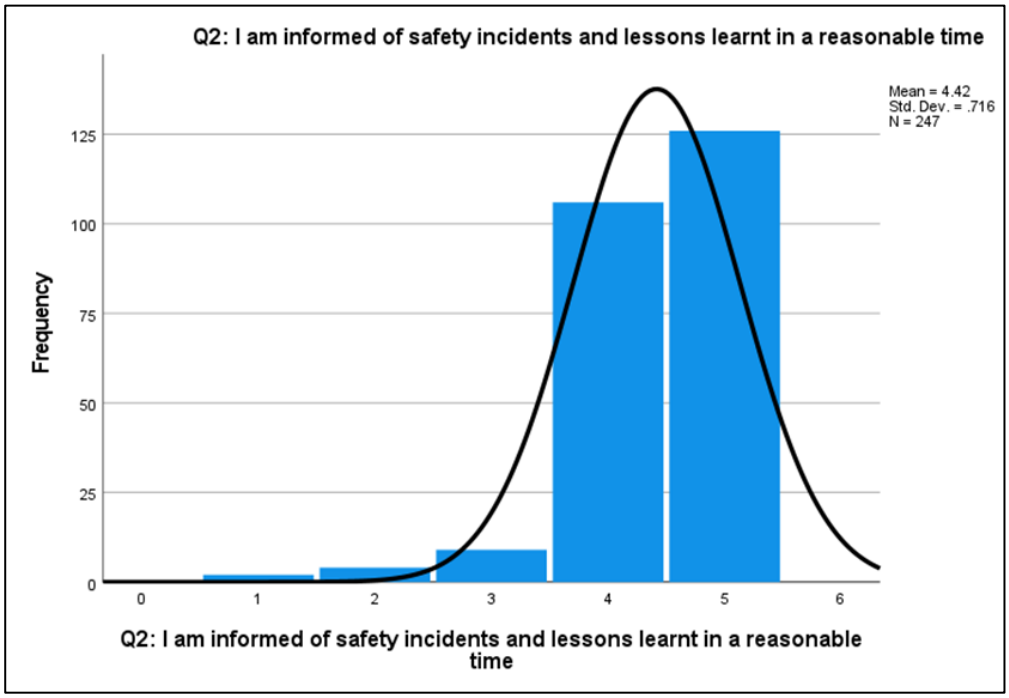


Figure 4-5: Histogram - Question 2

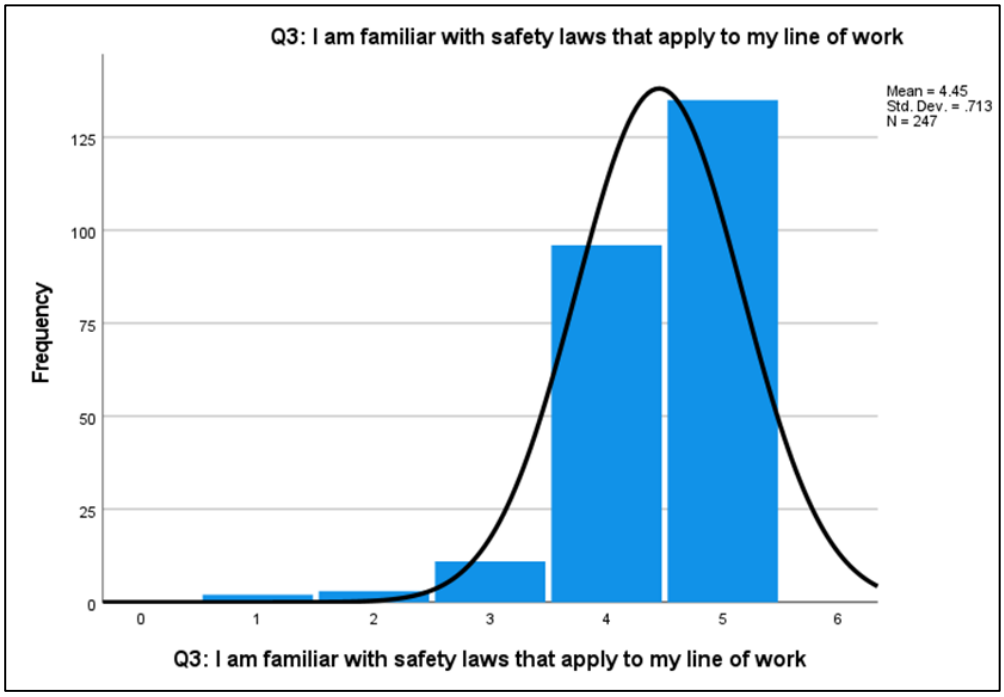


Figure 4-6: Histogram - Question 3

A visual inspection of the histograms generated for all 14 questions of the employee safety perception survey confirms the results obtained from the kurtosis and skewness calculations. Distinct tails on the left are observed for all questions,

indicated negatively skewed distribution, whilst the narrow peaks indicate high values of kurtosis. Histograms for all questions are presented in Appendix G.

4.2.2. Reliability

The internal consistency/reliability of the employee safety perception survey was calculated using Cronbach's equation as illustrated in (4-1 (Bland and Altman, 1997).

$$\alpha = \frac{k}{k-1}\left(1 - \frac{\sum s_i^2}{s_T^2}\right) \qquad (4\text{-}1)$$

Where k = number of items

s_i^2 = variance of item i

s_T^2 = total variance

The calculation of Cronbach's alpha was performed using the SPSS software package. Cronbach's alpha coefficient is mathematically restricted to $-1 < \alpha < 1$ and Bland and Altman (1997) indicate that a value greater than 0.7 is sufficient to indicate a sufficiently high degree of internal consistency, and consequently a sufficiently high degree of reliability.

Table 4-3: Cronbach's alpha reliability results from SPSS

Number of items	Cronbach's alpha
14	0.929

The Cronbach's alpha value obtained from SPSS is 0.929 indicating that 92.9% of the variability observed in the results of the 14 questions of the survey, combined, should be considered internally consistent. This value is above 0.7 and extremely close to one, indicating the data is highly internally consistent.

4.2.3. Non-parametric statistical testing

Boone and Boone (2012) recommend the following statistical testing methods for Likert type data, however, due to the results of the normality tests i.e. the significant

deviations from Gaussian distribution, the non-parametric test methods were employed.

Table 4-4: Statistical methods for Likert type data (Boone and Boone, 2012)

Analysis method	Non-parametric	Parametric
Central Tendency	Median/mode	Mean
Variability	Frequencies	Standard deviation
Association	Kendall tau B/C	Pearson's *r*
	Chi-square	ANOVA, t-test, regression

Measures of central tendency

The median is defined as "the point below and above which 50 percent of the scores in a distribution fall−in short, the midpoint" and the mode is defined as "the most frequent score in a distribution" (Fraenkel and Wallen, 2011). The median and mode data for the employee perception survey was calculated using SPSS and is presented in Figure 4-7 and Table 4-5.

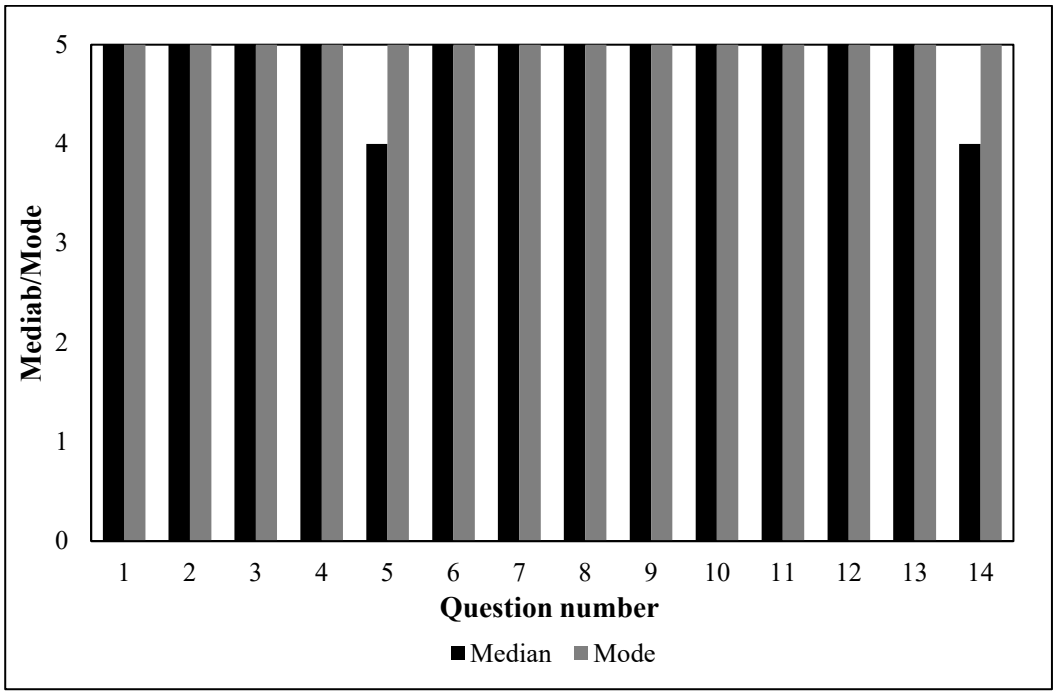


Figure 4-7: Measures of central tendency - median and mode

Table 4-5: Measures of central tendency - median and mode

	Question number													
Parameter	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**
Median	5	5	5	5	4	5	5	5	5	5	5	5	5	4
Mode	5	5	5	5	5	5	5	5	5	5	5	5	5	5

Variability

The degree of variability in the data was established using frequency and is presented in Table 4-6: Employee survey frequency data.

Table 4-6: Employee survey frequency data

Question	Strongly Agree	Agree	Neutral	Disagree	Strongly disagree
1	140	96	7	1	3
2	126	106	9	4	2
3	135	96	11	3	2
4	140	94	9	2	2
5	114	111	14	5	3
6	150	84	9	2	2
7	178	62	5	0	2
8	152	89	4	0	2
9	124	100	19	1	3
10	190	55	0	1	1
11	164	72	5	3	3
12	170	70	4	2	1
13	150	84	10	1	2
14	123	100	15	7	2

Figure 4-8 presents the frequency data as percentages of the total number of responses.

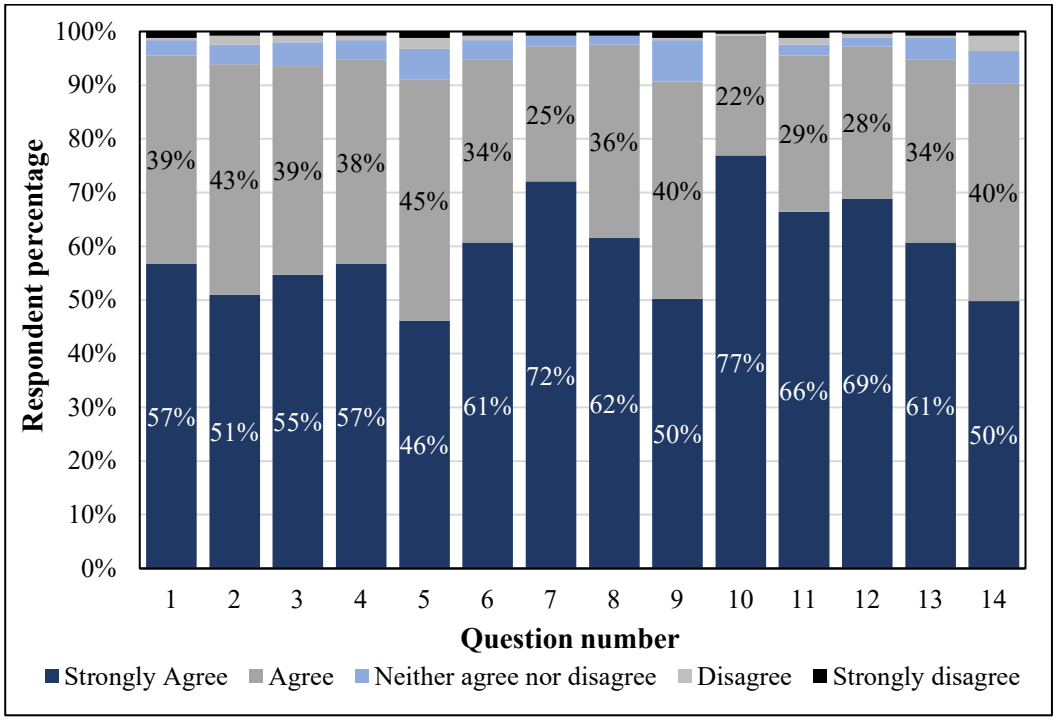


Figure 4-8: Employee survey frequency data (percentage basis)

The results were further summarized by aggregating 'strongly agree' and 'agree' as well as 'strongly disagree' and 'disagree' response and is presented in Figure 4-9.

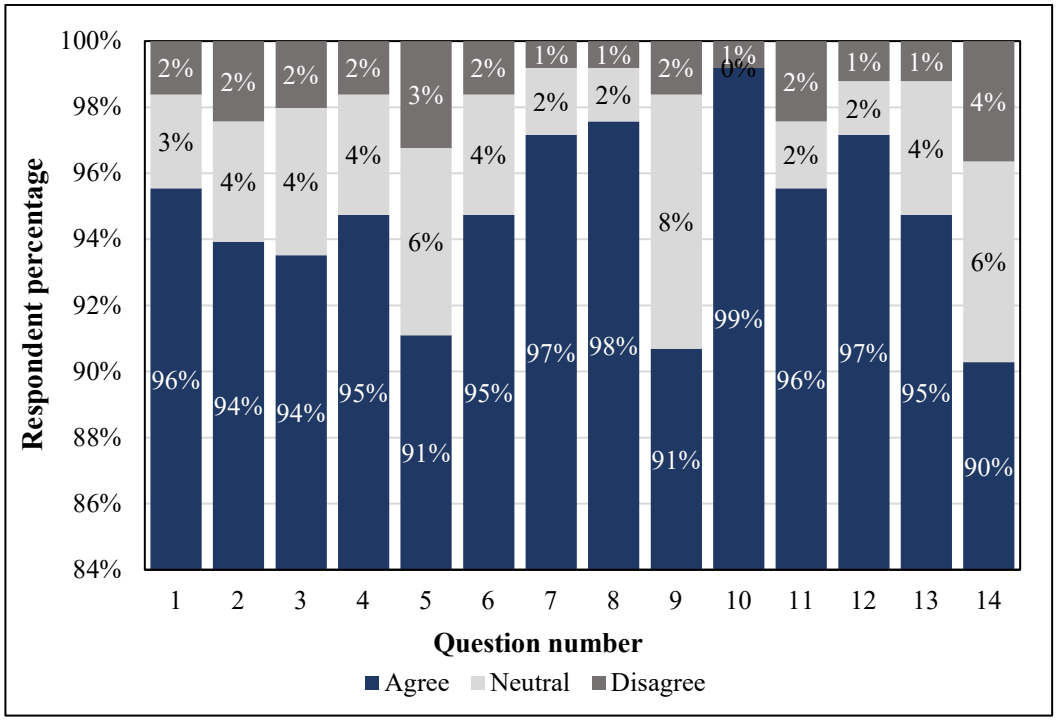


Figure 4-9: Employee survey frequency data (aggregated agree and disagree)

The data obtained from the surveys were categorised into three main sections, 'Awareness', 'Zero Harm' and 'Safety Perception'. The data for these categories were then summed and normalised to the maximum possible score for the category as is presented in Figure 4-10.

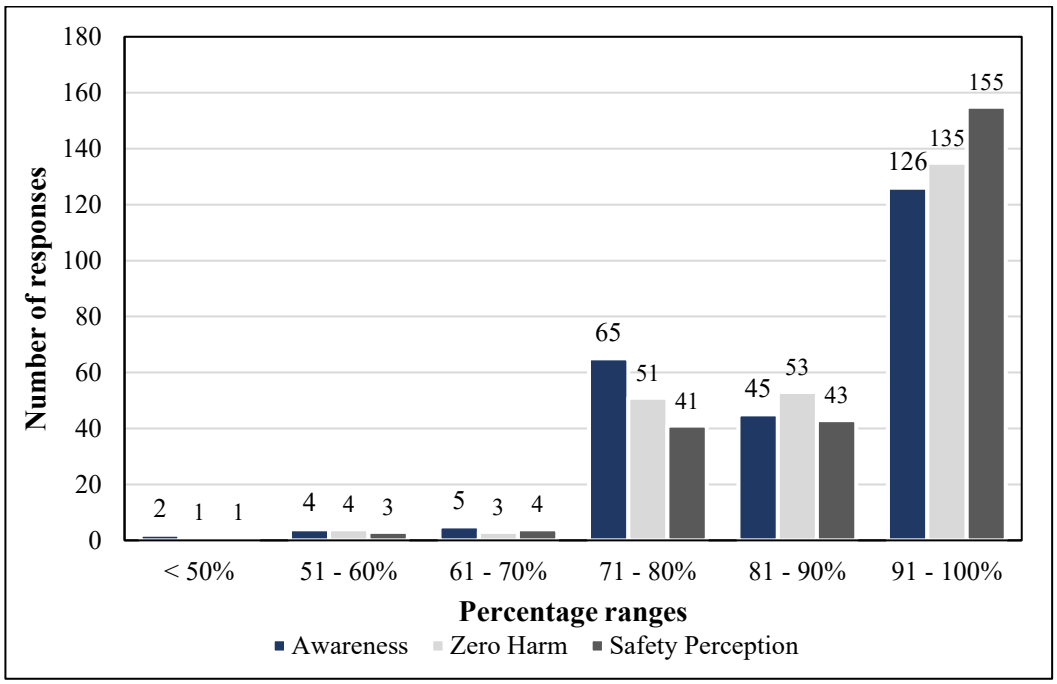


Figure 4-10: Aggregated Survey Category data

4.2.4. Association

The tests for association suggested by Boone and Boone (2012), using non-parametric methods, are the Kendall tau B/C methods, however, it was decided to use the Kruskal-Wallis test in addition to the Kendall tau B/C methods. The applicability of this test method is confirmed by both Vargha and Delaney (1998) as well as Brown and Hettmansperger (2002).

The null hypothesis postulated within SPSS is the distribution of the results of each question is the same across the applicable Company XYZ: Mining collieries. The level of significance utilised for the test was 0.05, and the results of the test for the first questions one and two presented below (complete results presented in Appendix H):

Table 4-7: Kruskal-Wallis test results (Questions 1 and 2)

Null Hypothesis	Test	Sig.	Decision
The distribution of Q1: I am aware of my departmental safety procedure is the same across categories of QA: Colliery.	Independent-Samples Kruskal-Wallis Test	0,258	Retain the null hypothesis.
The distribution of Q2: I am informed of safety incidents and lessons learnt in a reasonable time is the same across categories of QA: Colliery.	Independent-Samples Kruskal-Wallis Test	0,159	Retain the null hypothesis.

4.2.5. Correlation

The Kendall tau B method was selected to measure the correlation between the individual survey questionnaires. An extract of the results is illustrated in Table 4-8, and the comprehensive results are provided in Appendix I.

The results of the statistical analysis presented within this chapter are discussed in detail in Chapter Five.

Table 4-8: Kendall tau B results

		Q1	Q2	Q3	Q4	Q5	Q6
Q1	**Correlation Coefficient**	1.000	0.608	0.580	0.625	0.513	0.353
	Sig. (2-tailed)		0.000	0.000	0.000	0.000	0.000
	N	247	247	247	247	247	247
Q2	**Correlation Coefficient**	0.608	1.000	0.607	0.601	0.490	0.373
	Sig. (2-tailed)	0.000		0.000	0.000	0.000	0.000
	N	247	247	247	247	247	247

4.3. EMPLOYEE PERCEPTION SURVEY: RESULTS

4.3.1. Response rate

The minimum calculated sample size required was 239 participants, hence 250 surveys were administered to the relevant target group. A response of 247 was obtained, which implies a response rate of 98.8% against the required 95.6%. The response received was more than the minimum requirement and is therefore sufficient to represent the population being studied in this research. The complete set of response data is presented in Table F- 1: Employee perception survey response data, in Appendix F.

4.3.2. Participant profile

Participants were profiled based on their years of experience in the mining industry as well as their respective mine collieries. Age and gender were excluded from the participant profiles to ensure complete confidentiality.

Mining colliery

The survey was administered on two days, at the safety induction training sessions. These safety training sessions are conducted per colliery as far as possible (two collieries are sometimes trained if the numbers can be accommodated), apart from minute numbers from other collieries present at the training due to availability issues. Company XYZ currently runs 6 mining collieries, which will be renamed to collieries A – F, to maintain the confidentiality of Company XYZ. The distribution of the responses obtained is presented in Figure 4-11.

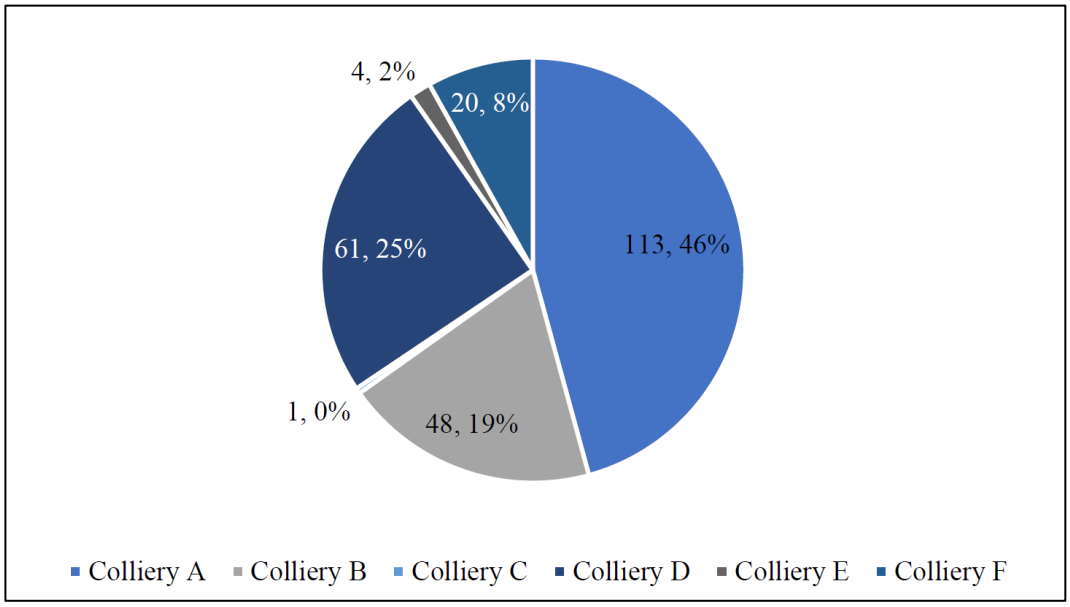


Figure 4-11: Survey responses per mine colliery

Mining experience

The design of the employee perception survey included provision for capturing the respondents' years of working experience within the mining environment. The options presented to the participants were < 1 year, 1 – 5 years, 5 – 10 years, and > 10 years of experience. The distribution of years of experience is presented in Figure 4-12. The experience distribution per mine colliery is presented in Figure 4-13.

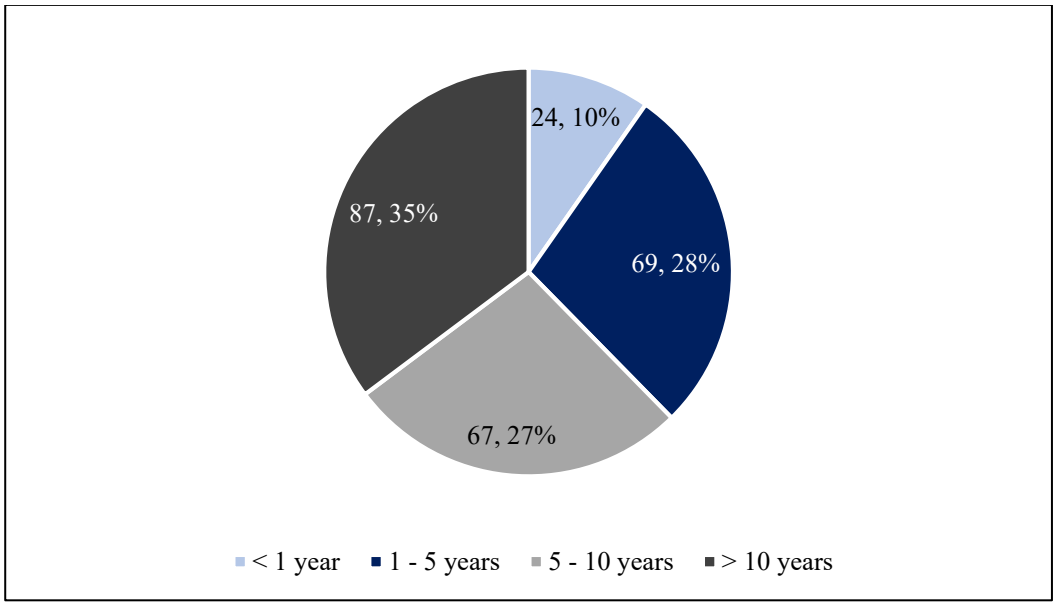


Figure 4-12: Respondent years of experience

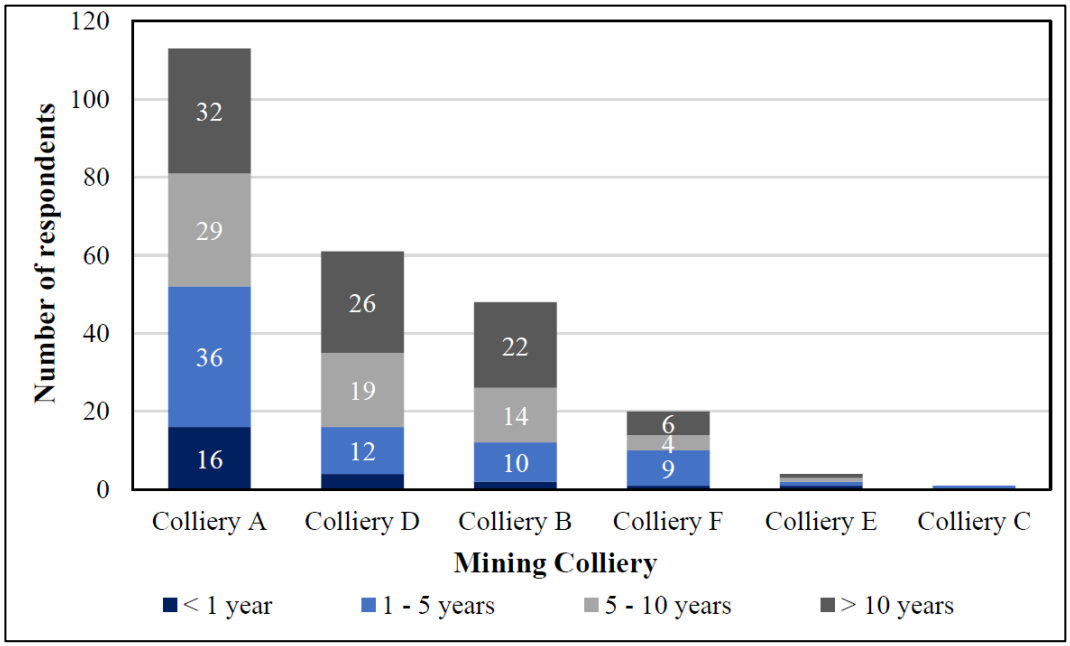


Figure 4-13: Respondent years of experience per colliery

4.3.3. General comments

In addition to Likert scale items, and the experience and colliery questions, the survey contained an open-ended question which was used to gather general comments/suggestions the respondents may have had, on the improvement of safety performance. A total of 107 responses were received to this question, and the responses were filtered and categorised into 16 identified categories.

Table 4-9: General comment categories

Category	Number of responses	Percentage of total responses
Management relationship	2	2%
Production targets pressure	15	14%
Test new systems	1	1%
Safety culture	1	1%
Safety awareness	20	19%
Less paperwork	1	1%
Digitalisation	1	1%

Category	Number of responses	Percentage of total responses
Safety training	15	14%
Communication	19	18%
Hazard Identification	12	11%
Remuneration	4	4%
Housekeeping	1	1%
PPE	1	1%
Technical training	6	6%
Equipment	3	3%
Teamwork	5	5%

Figure 4-14 illustrates the major categories identified from the general comments provided in the survey response.

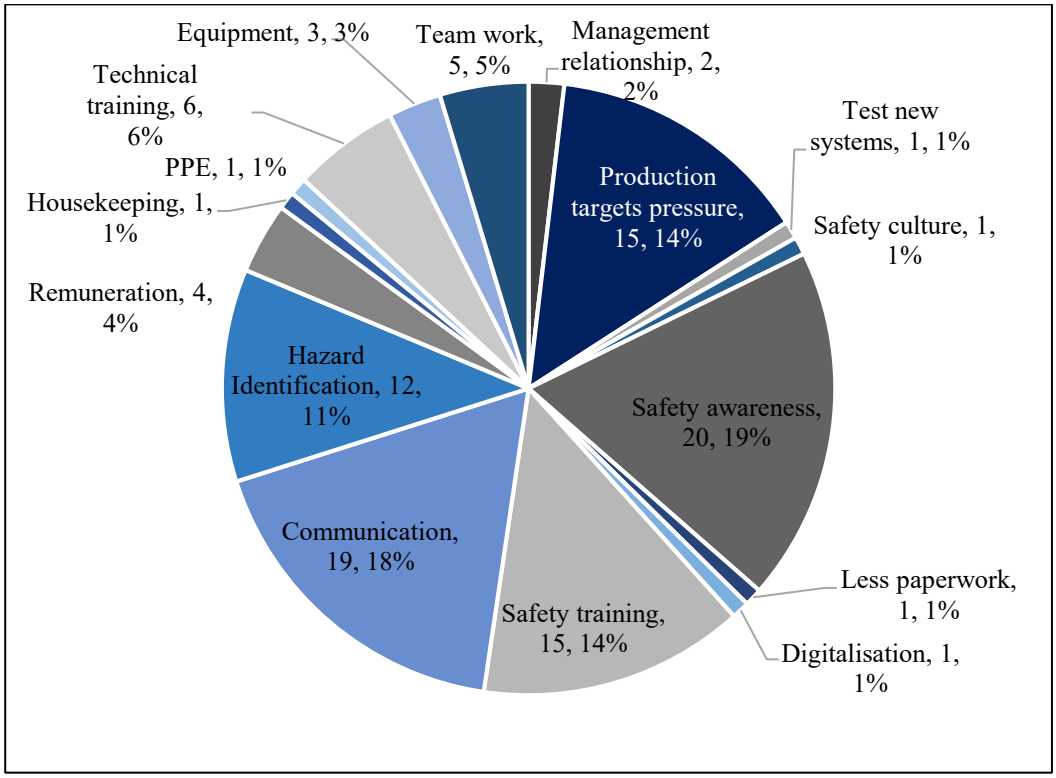


Figure 4-14: Comment category frequency

4.4. INCIDENT INVESTIGATION ANALYSIS

4.4.1. Incident database

Company XYZ: Mining follows the formal RCA process during incident investigations. An analysis of 191 occupational safety incident investigation/RCA reports over three fiscal years (FY-17 to FY-19) was performed, across the six mining collieries, to gain insight into the common root cause factors, the organisational, workplace and personal factors, control failure prevalence, incident classification, occupation groups of injured personnel and time of incidents.

In addition to the above analyses, the RCA/investigation report quality was assessed, by allocating a score out of three points, based on the content and completeness of the report.

4.4.2. Fiscal year

The number of incident investigation reports analysed per fiscal year is illustrated below:

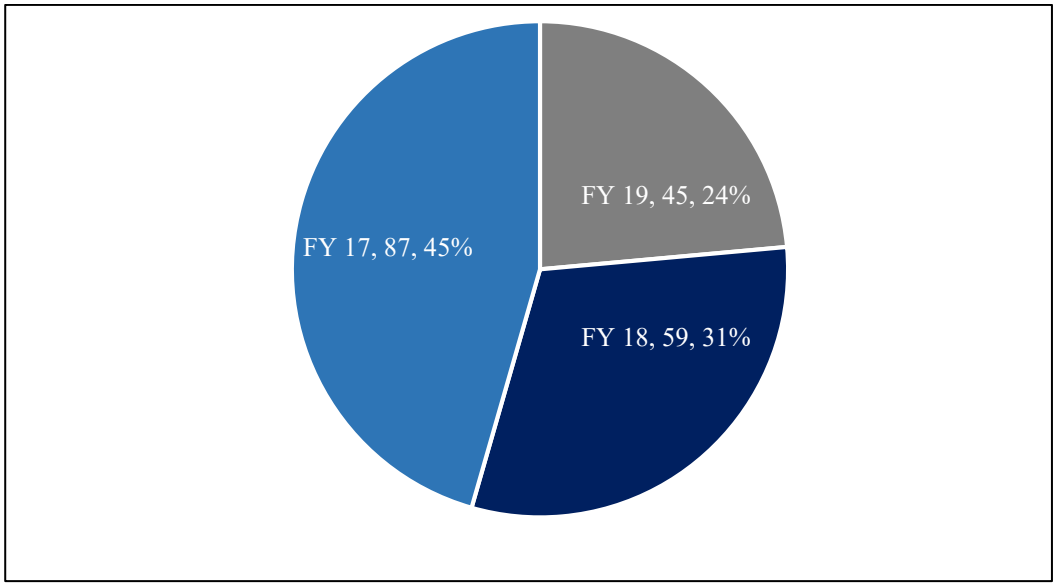


Figure 4-15: Number of incident investigation reports analysed per FY

4.4.3. Mining colliery

An analysis was performed to understand the occupation safety incident prevalence in the six mining collieries per financial year. This data is presented in Figure 4-16.

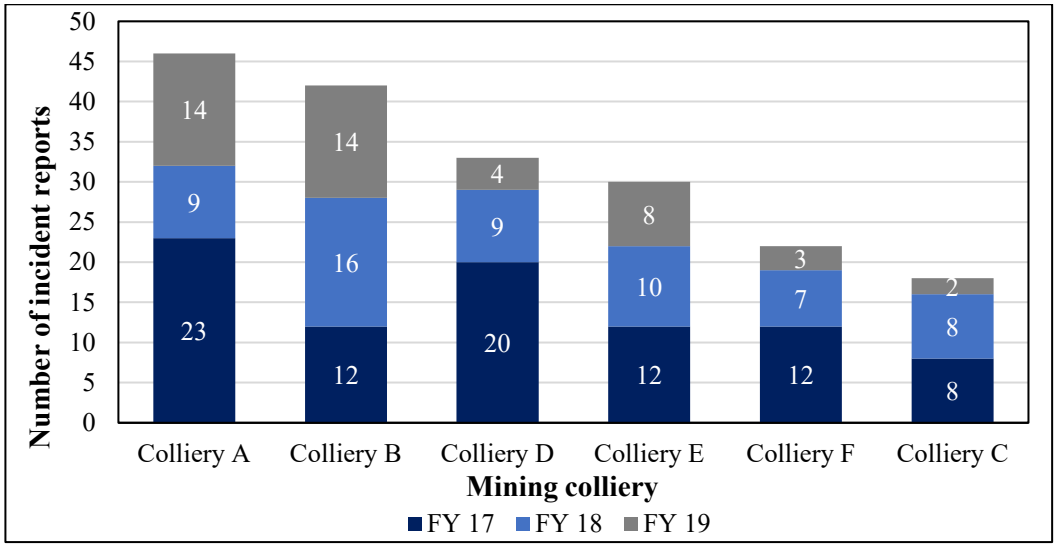


Figure 4-16: Mining colliery incident reports per FY

4.4.4. Occupation group

The occupations of the personnel involved in occupational safety incidents were captured from incidents per fiscal year, where available. and the eight most prevalent occupations (comprising 86% of total incidents) are presented in Figure 4-17.

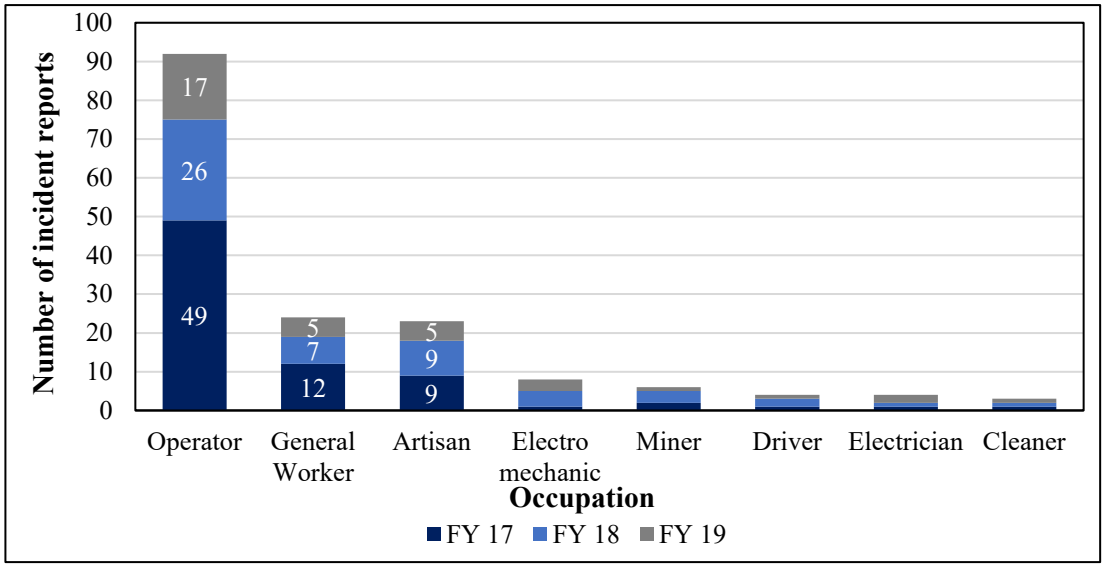


Figure 4-17: Occupation distribution - Incident investigation reports per FY

4.4.5. Incident classification

Occupational safety incidents at Company XYZ are classified as First Aid Cases (FAC), Medical Treatment Cases (MTC), Restricted Work Day Cases (RWDC), Lost Work Day Case (LWDC) and fatalities, in increasing severity. All categories of incidents except FACs (i.e. MTCs, RWDS, LWDCs and fatalities) are considered recordable injuries and are accounted for in the Recordable Case Rate (RCR) calculations. The number of incidents reported under each category is presented in Figure 4-18 and Figure 4-19, per financial year. The classification of two incidents that occurred in FY-17 and FY-19 were not stated in the incident investigation reports and have been represented as unknown.

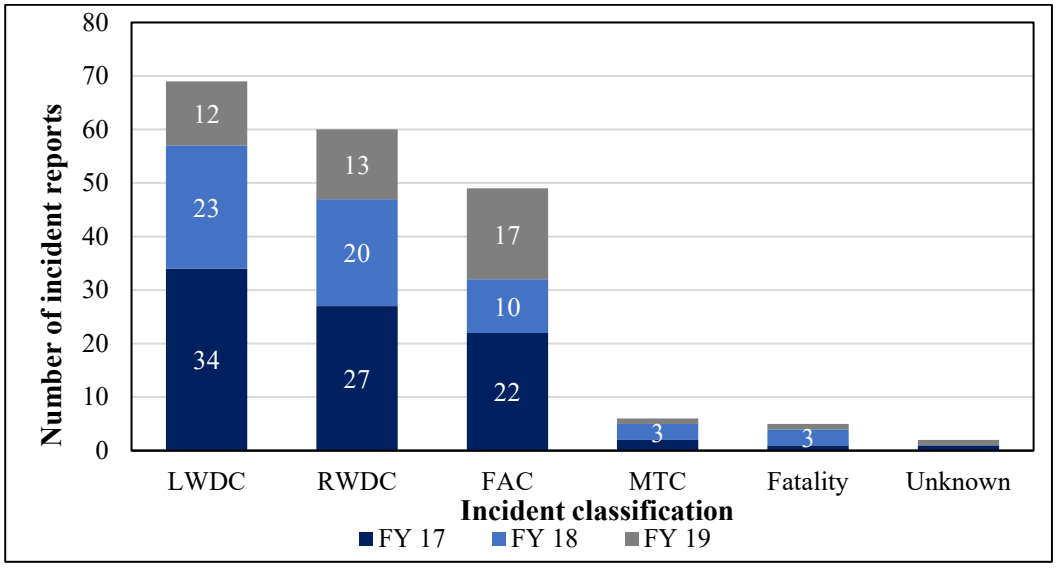


Figure 4-18: Incident classification per FY

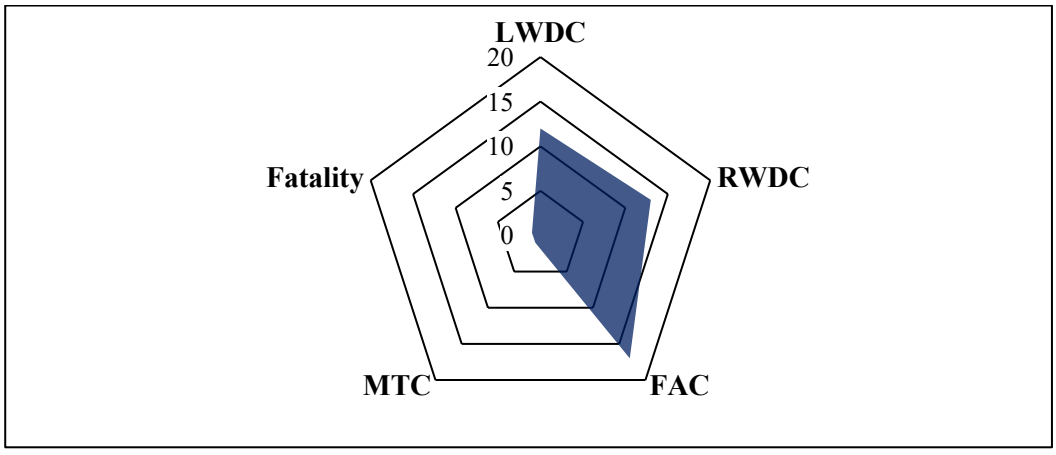


Figure 4-19: Distribution of identified incident classification

4.4.6. Experience distribution

The number of years of experience of the personnel involved in occupational safety incidents ranges from one month to 40 years. The numbers of years of experience were therefore categorised into four different ranges, in line with the employee perception survey question on experience to allow for comparison. The distribution of incidents according to years of experience are presented in Figure 4-20 and Figure 4-21.

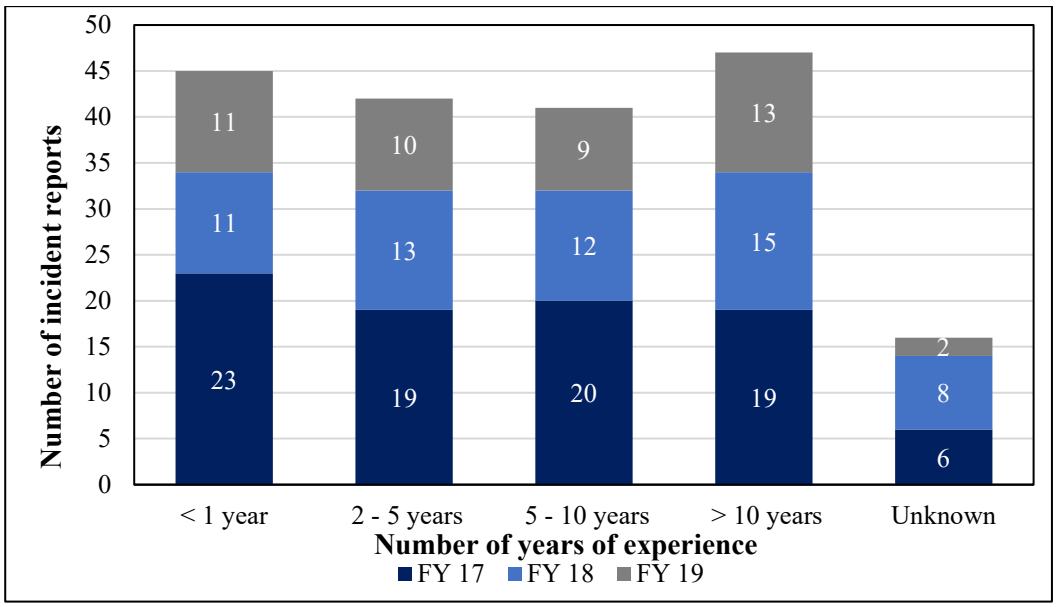


Figure 4-20: Incident distribution with years of experience per FY

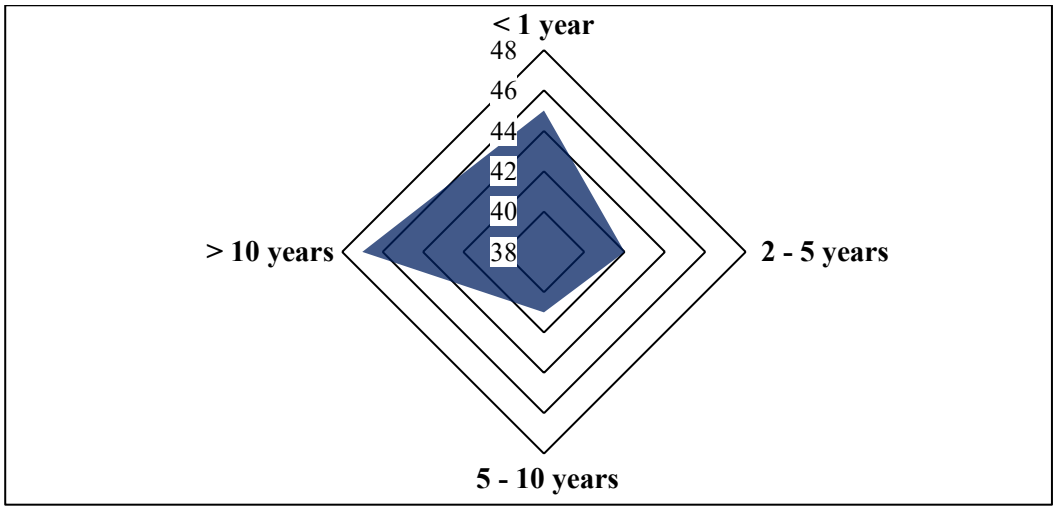


Figure 4-21: Distribution of years of experience

4.4.7. Incident time of day

The times of occurrence of incidents were recorded and grouped into hour time intervals, to investigated possible relationships between the time of day and the numbers of incidents occurring. The results of this analysis are presented in Figure 4-22 and Figure 4-23.

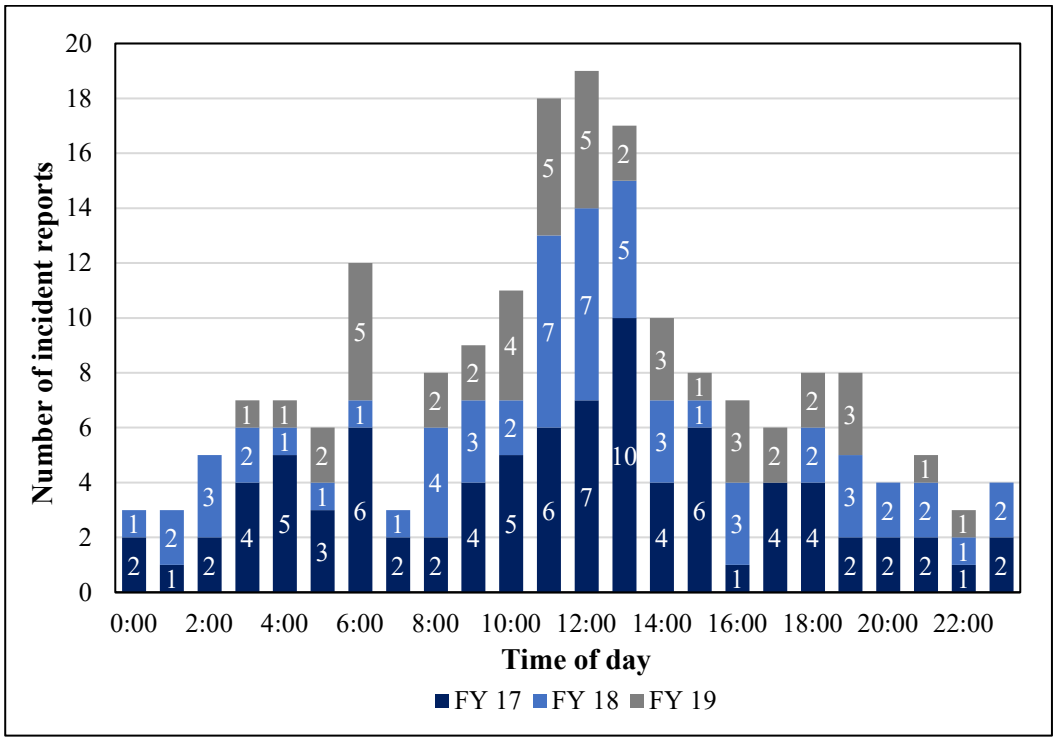


Figure 4-22: Incident prevalence by the time of day per FY

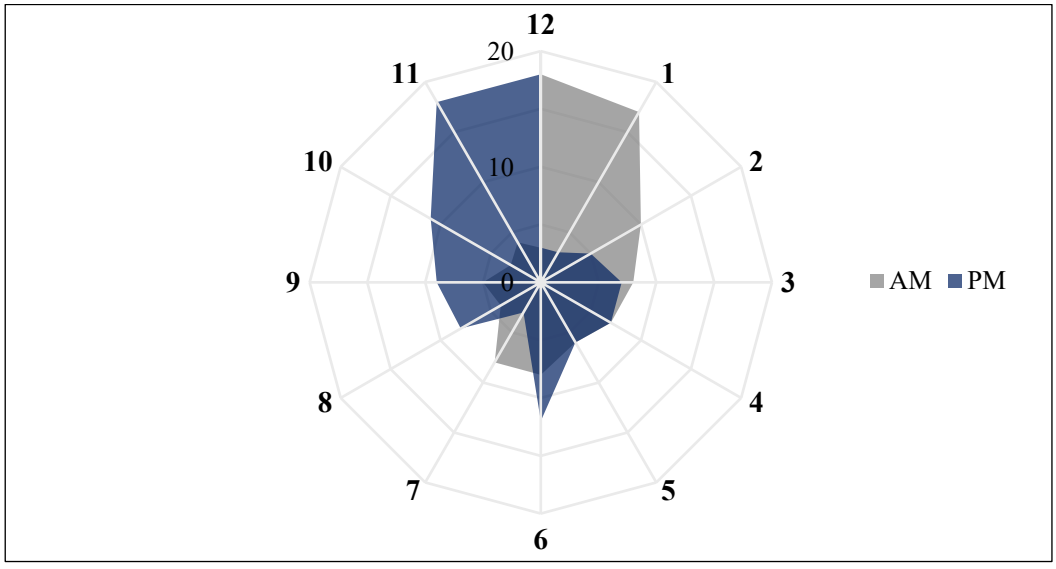


Figure 4-23: Time prevalence (AM and PM)

4.4.8. Incident day of week

The days of the week on which the incidents occurred were recorded and the analysis of this data is presented in Figure 4-24 and Figure 4-25.

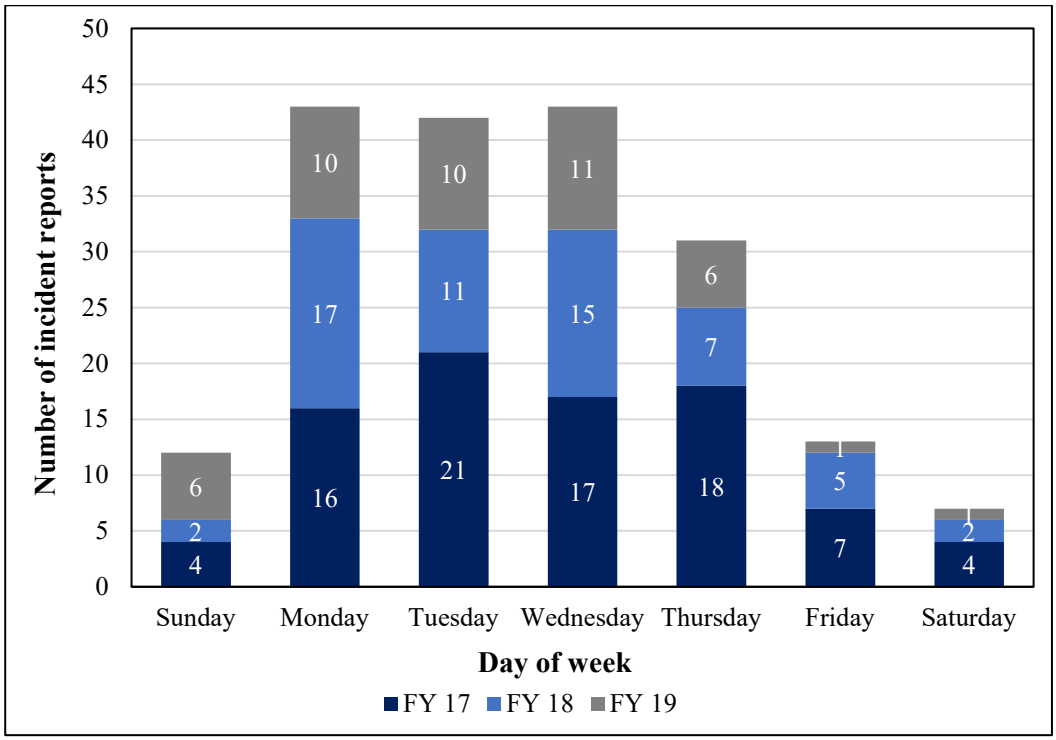


Figure 4-24: Incident prevalence by day of the week per FY

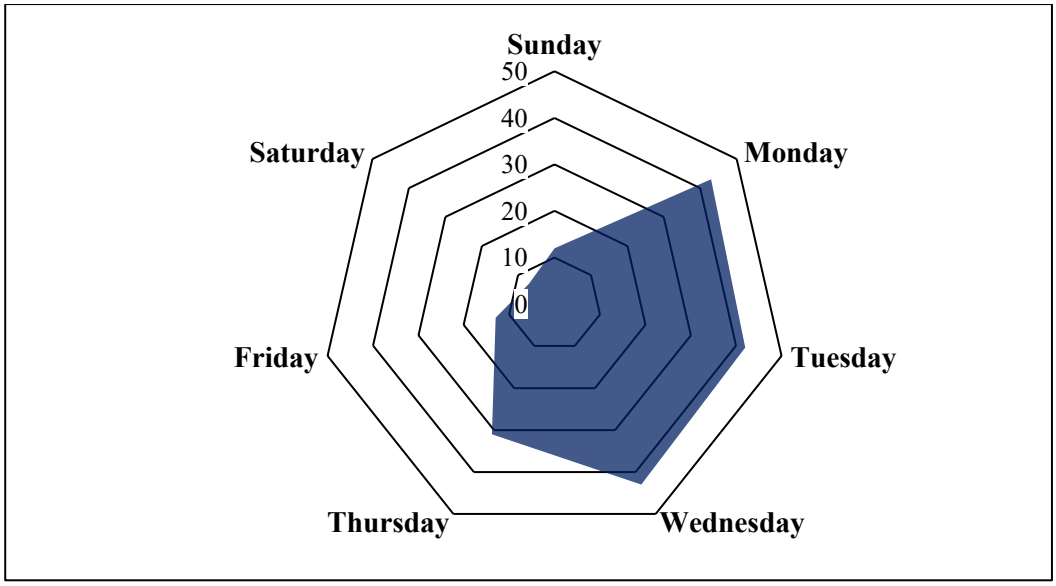


Figure 4-25: Total incident prevalence by day of week

4.4.9. Bow-tie control failure prevalence analysis

The incident investigation process includes a 'Barrier Failure analysis' section, in which the risk mitigation control failures are listed according to the level of control, namely, engineering controls, administrative controls and personal protective equipment (PPE) as presented in Figure 1-1.

Engineering controls

A total of 15 engineering-type control failures were identified from the incident investigation reports. There are 27 engineering-type barriers/controls put in place to prevent the occurrence of an occupational safety incident. This translates to a 56% failure of engineering controls. There were 174 engineering control failures identified, categorised into the abovementioned 15 controls, from the 191 investigation reports analysed. Figure 4-26 illustrate the control failure prevalence of the top 90% of the total engineering control failures observed.

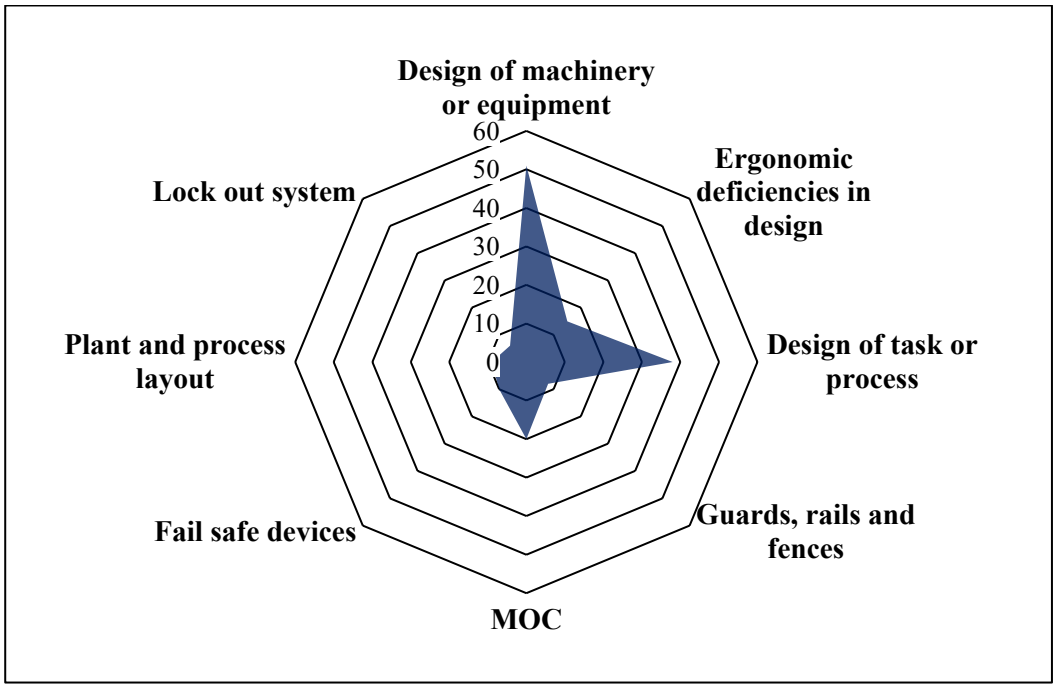


Figure 4-26: Engineering control failure prevalence

Administrative controls

There were 27 administrative control types identified as failures from the incident investigation reports. Company XYZ: Mining has identified a total of 27 administrative controls, hence all controls were identified during incident investigations. The overall administrative control failures identified amounted to 631. The top 13 administrative control failures (87% of total failures identified) are presented in Figure 4-27.

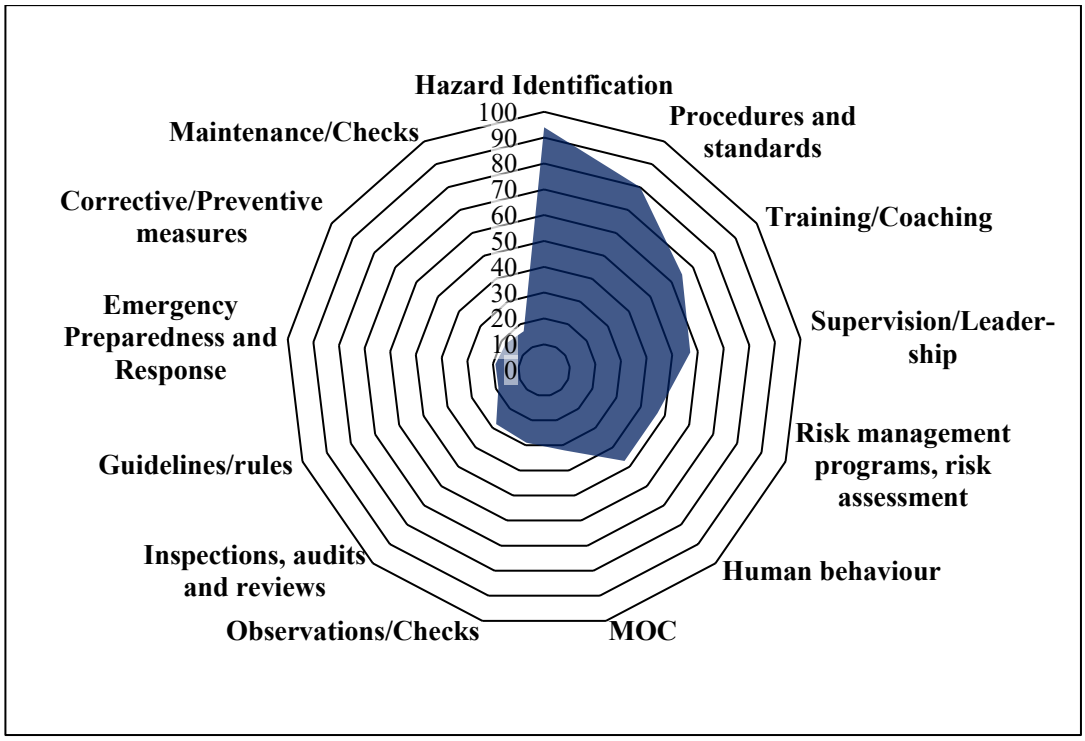


Figure 4-27: Administrative control failure prevalence

An analysis of the human behaviour, hazard identification and training and coaching controls is presented below, per fiscal year, to identify possible changes in the number of incidents attributed to these controls over time. These controls were selected based on the prevalence of recommendations identified from the general comments provided in the employee safety perception survey (see Section 0).

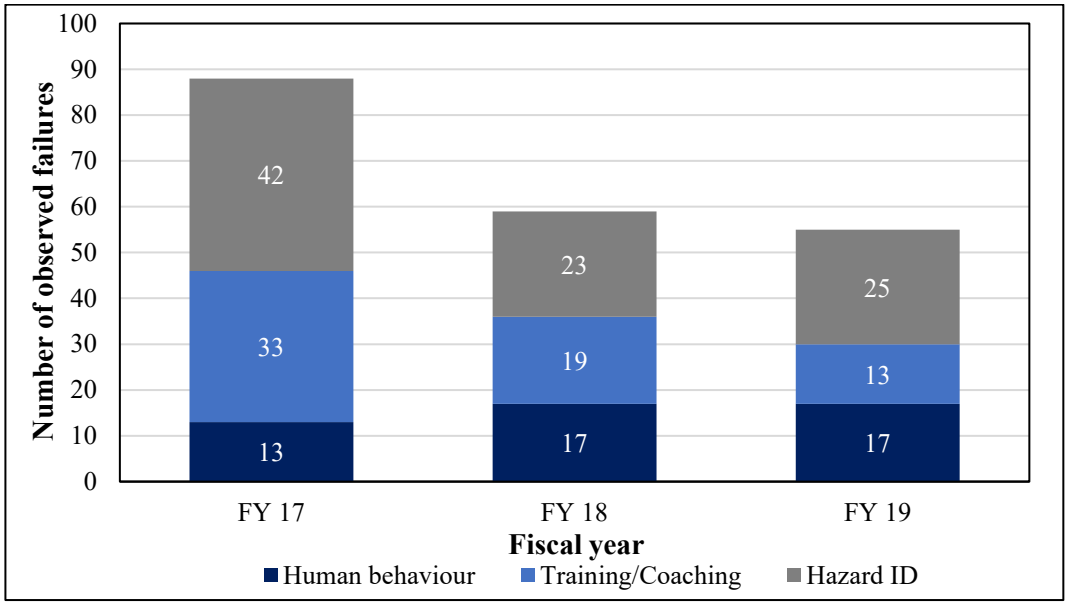


Figure 4-28: Human behaviour, Training and Hazard ID failures per FY

Personal Protective Equipment (PPE)

Incidents involving the lack of PPE/incorrect PPE totalled 11 for the period investigated.

Control failure type comparison

The three categories of control failures are summarised and presented in Figure 4-29, as a comparison to the theoretical hierarchy of controls presented in Figure 1-1.

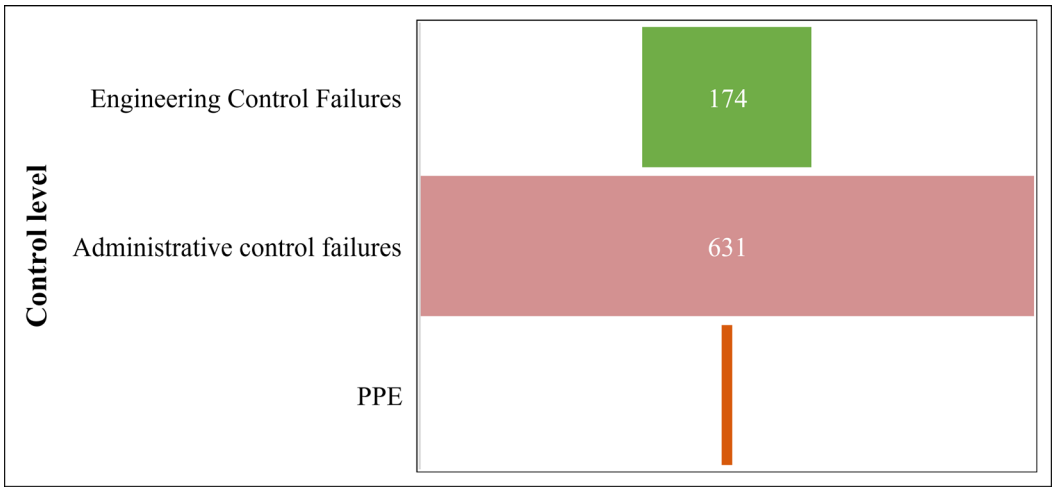


Figure 4-29: Control failure distribution (hierarchy of controls)

4.4.10. Contributing factors

An analysis of the number of organisational, workplace and personal factors was performed per fiscal year. This indicates at which level/s of the organisation the root causes lie. There was a large degree of variability observed in the factors identified within each level, and therefore no analysis was performed at a factor level. The results of this analysis are illustrated in Figure 4-30 and Figure 4-31.

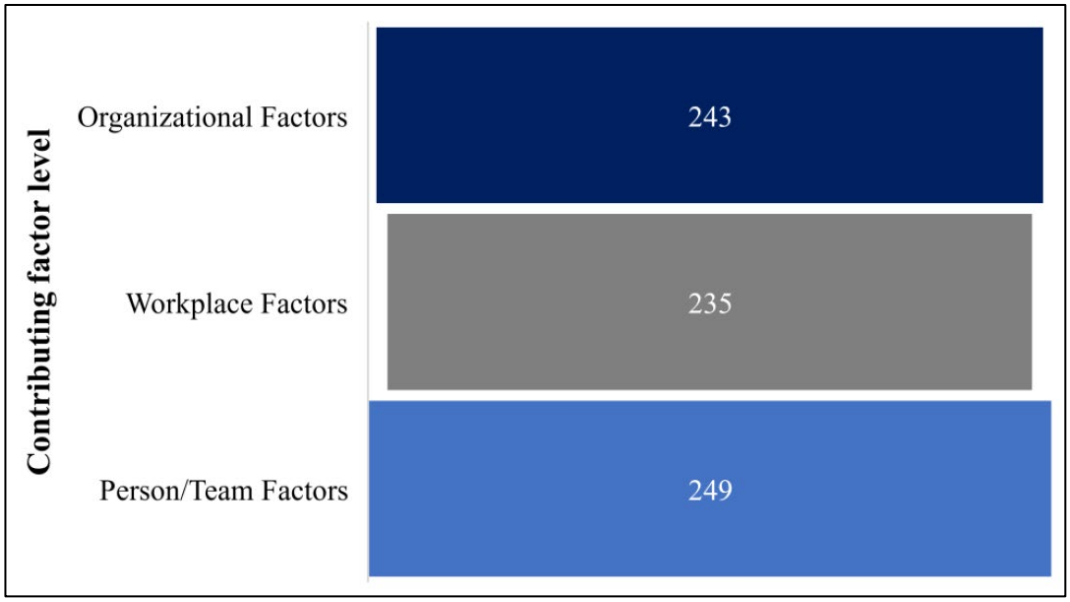


Figure 4-30: Analysis of contributing factors

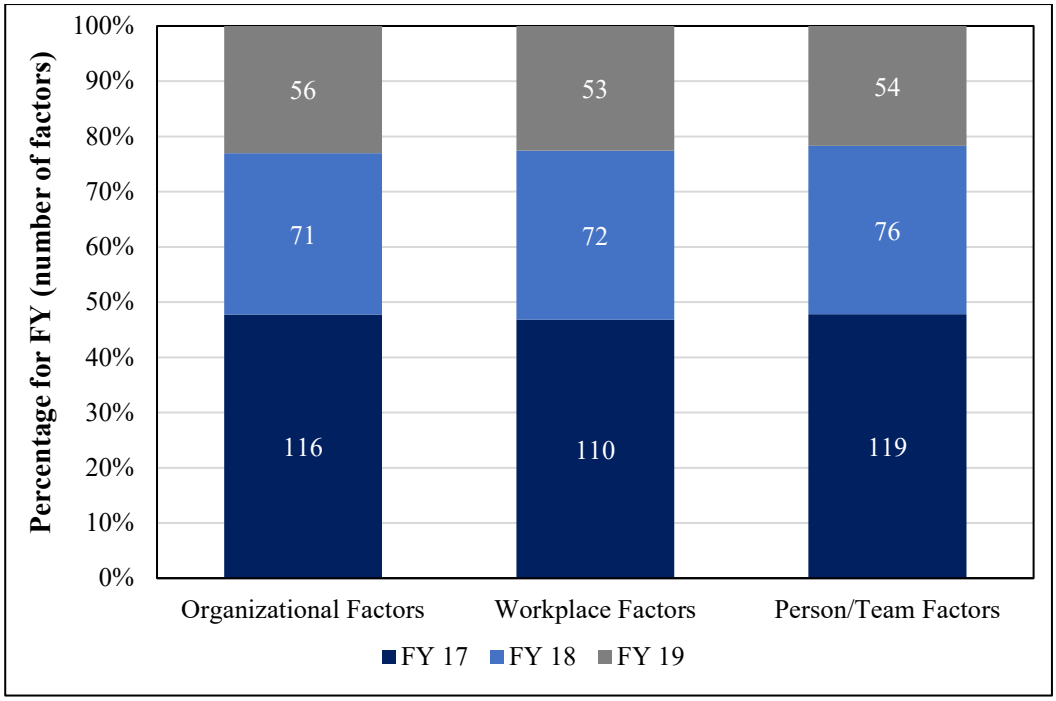


Figure 4-31: Contributing factors identified per FY

4.4.11. Investigation report quality

The following criteria were used to access the quality of the RCA incident investigation reports, with corresponding penalties, out of a total of four points allocated per incident report:

Table 4-10: Incident investigation report quality assessment criteria

Criteria	Penalty
Contributing factors	
o Incorrect identification of factors	-1
o Factors not identified	-1
Learnings	
o No incident learnings	-1
Barrier/control failures	
o Control failures not identified	-1
o Control failures incorrectly identified	-1

In line with the criteria and penalties presented in Table 4-10, the maximum possible penalty incurred was -3, hence the quality scores range between 1 and 4, based on the number of penalty points incurred.

The incident investigation quality scores, per FY, are presented in Figure 4-32 and Figure 4-33, and the distribution of the penalties are illustrated in Figure 4-34 and Figure 4-35.

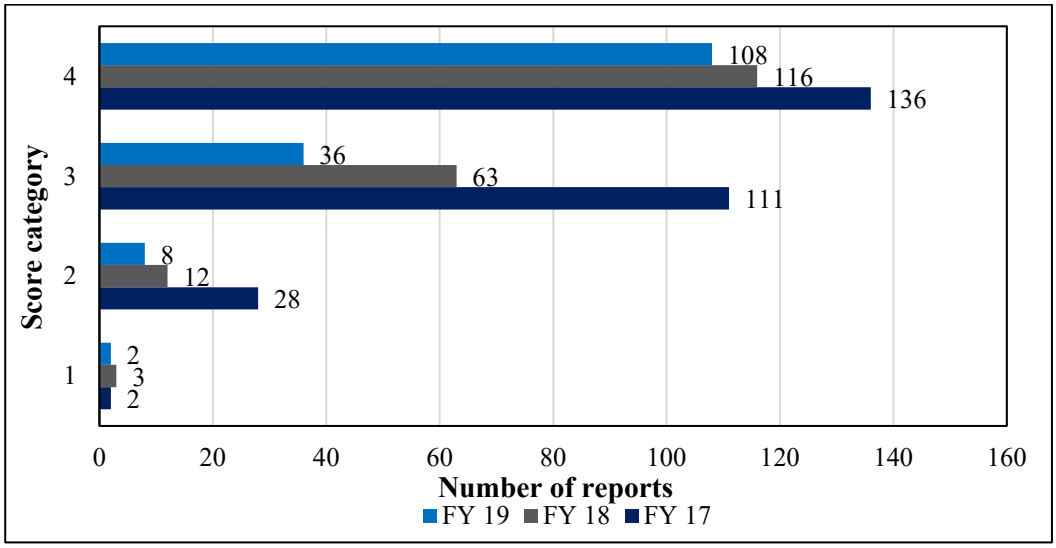


Figure 4-32: Incident report score distribution per FY

The proportion of each score range per FY is presented in Figure 4-33.

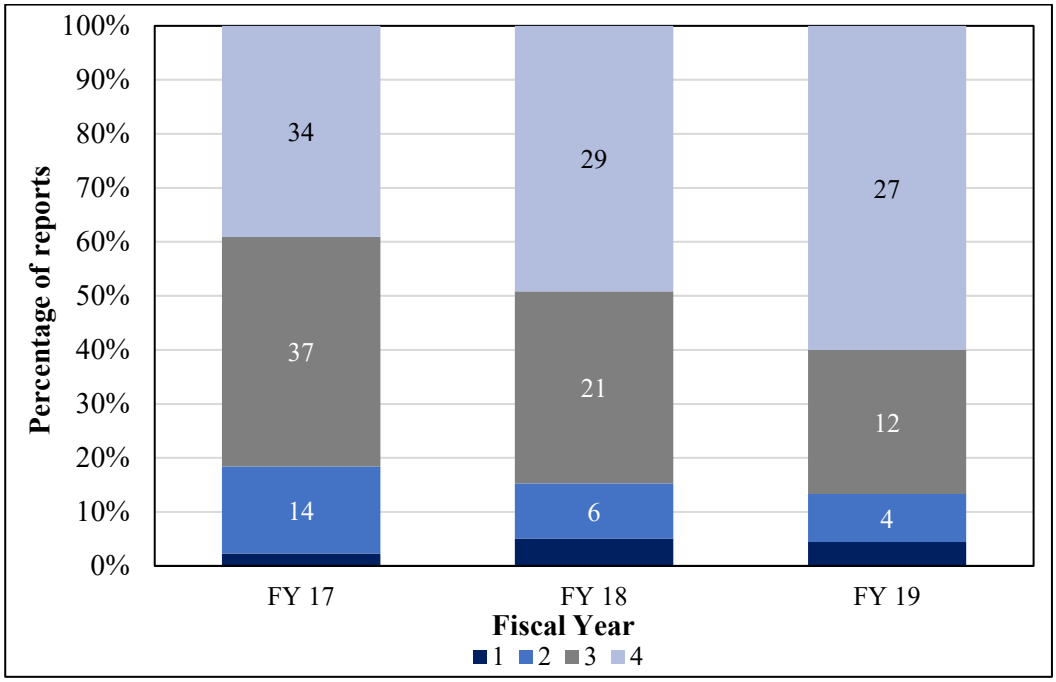


Figure 4-33: Distribution of scores per FY (percentage-based)

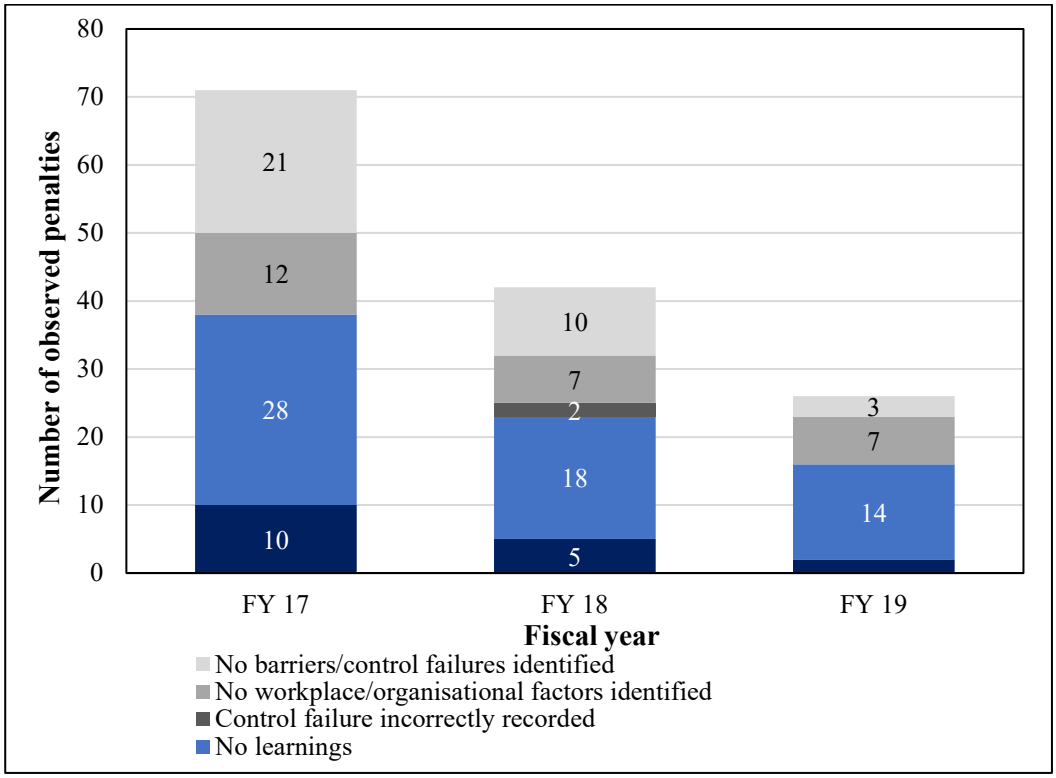


Figure 4-34: Distribution of incident report quality penalties per FY

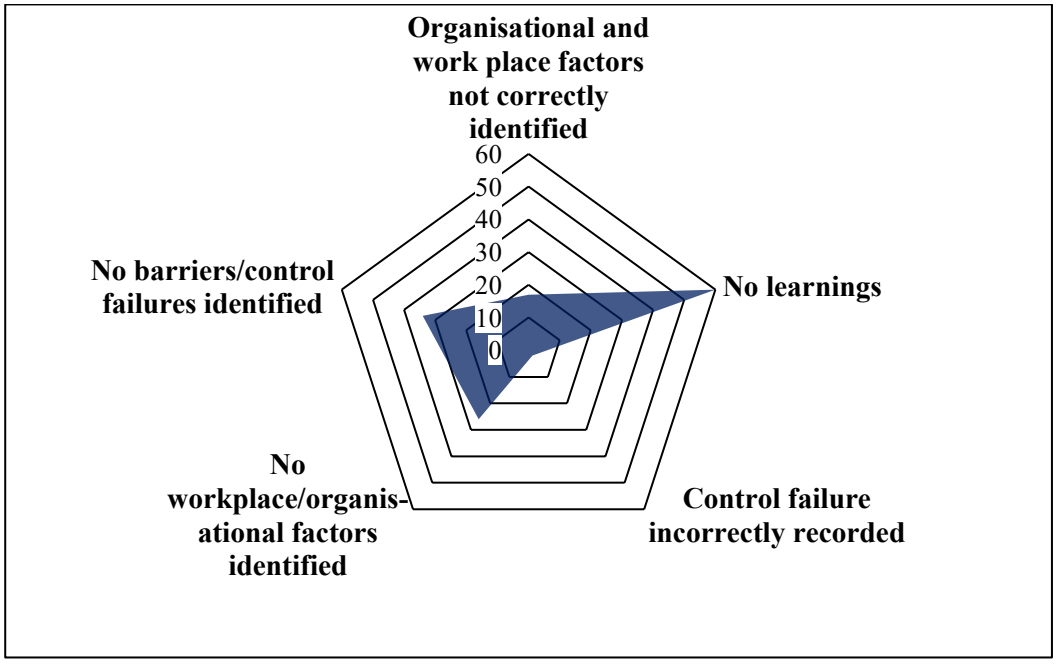


Figure 4-35: Total incident quality penalty prevalence

4.5. SAFETY CULTURE MATURITY ASSESSMENT

The Company XYZ safety culture maturity assessment is an in-depth evaluation of multiple factors and requires extensive time and resource allocation to be completed accurately. The services of external consultants were engaged to complete the assessment for colliery F, in 2016 and these results will be assumed to be indicative of the mining business unit, in its entirety, due to the organisation's resource, financial and time constraints.

The maturity assessment comprises 18 elements, against which colliery F was assessed. The 18 elements of the maturity assessment and the results of the assessment, relating to these elements are presented in Figure 4-36.

The overall HSE maturity results, based on the average of the 18 individual element scores, was 2.7 for HSE practices and 2.4 for HSE performance.

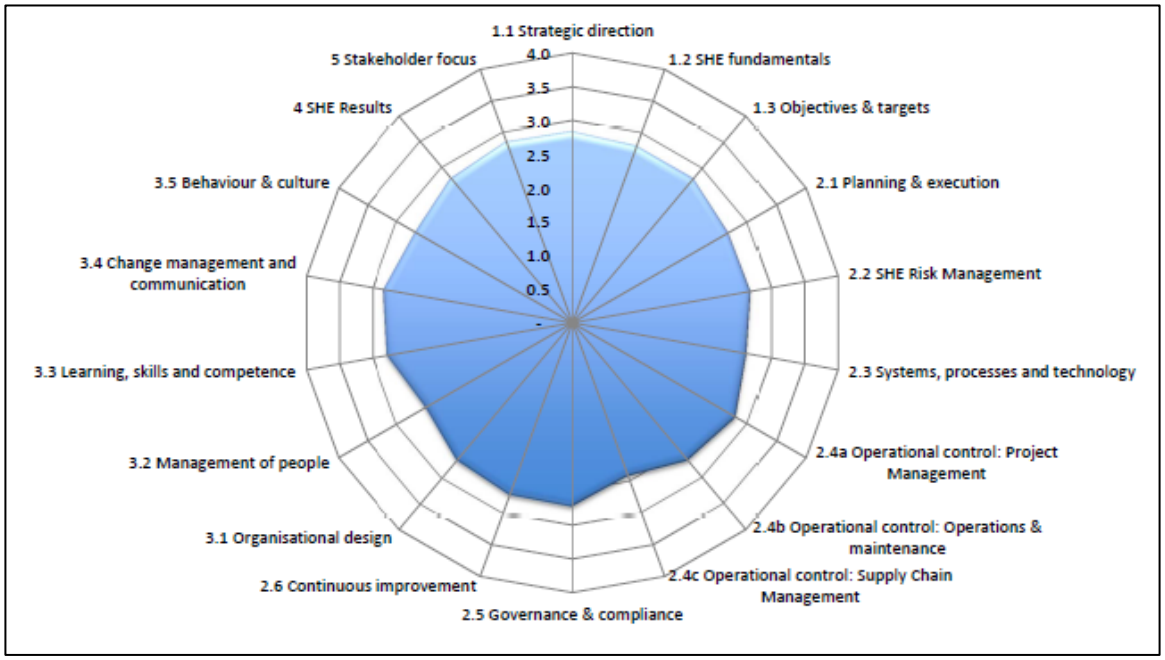


Figure 4-36: Maturity level per element - colliery F

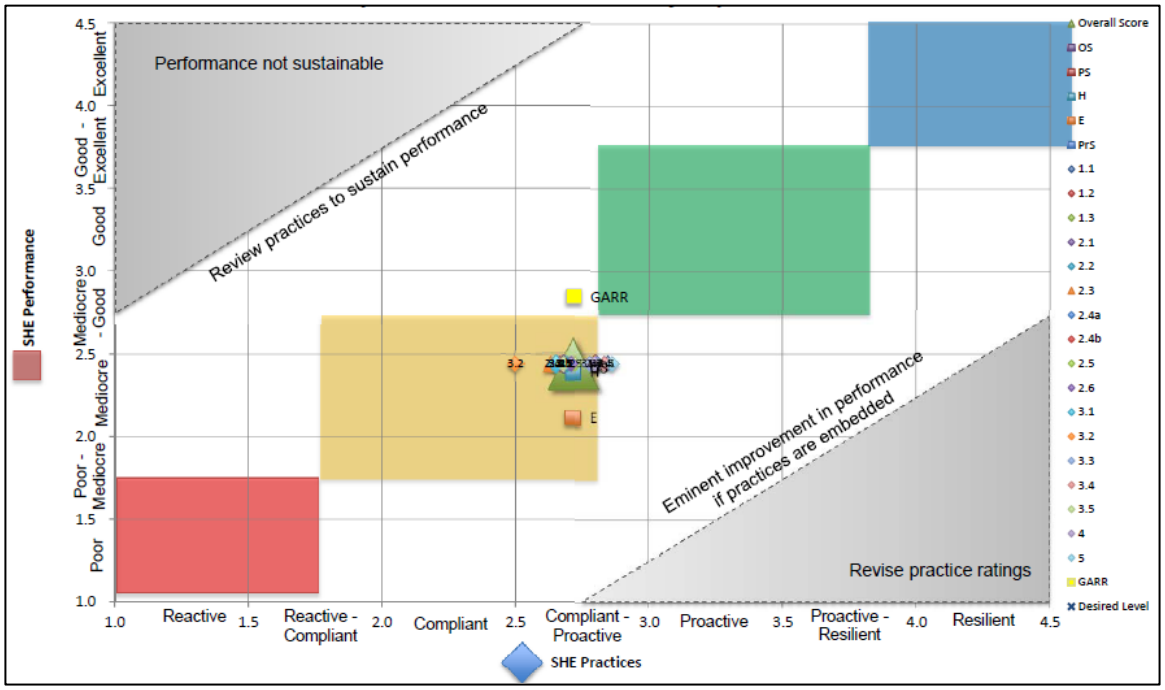


Figure 4-37: HSE maturity results

4.6. SAFETY KEY PERFORMANCE INDICATORS (KPIS)

The primary indicators of safety performance used by Company XYZ: Mining is the RCR and the LWDCR. The Mining safety KPIs are presented in Figure 4-38 and Figure 4-39, over 3 fiscal years (FY17 – FY19), against their respective targets, together with the numbers of recordable and lost workday case injuries.

The indicators of performance are calculated for the mining business as a whole and represent the aggregated case rates for all 6 collieries as well as support services provided to the direct mining operations, such as the maintenance workshop function, which is not directly involved in the mining process. The financial years depicted below, are in line with the results of the incident investigation report analyses present in section 4.4.

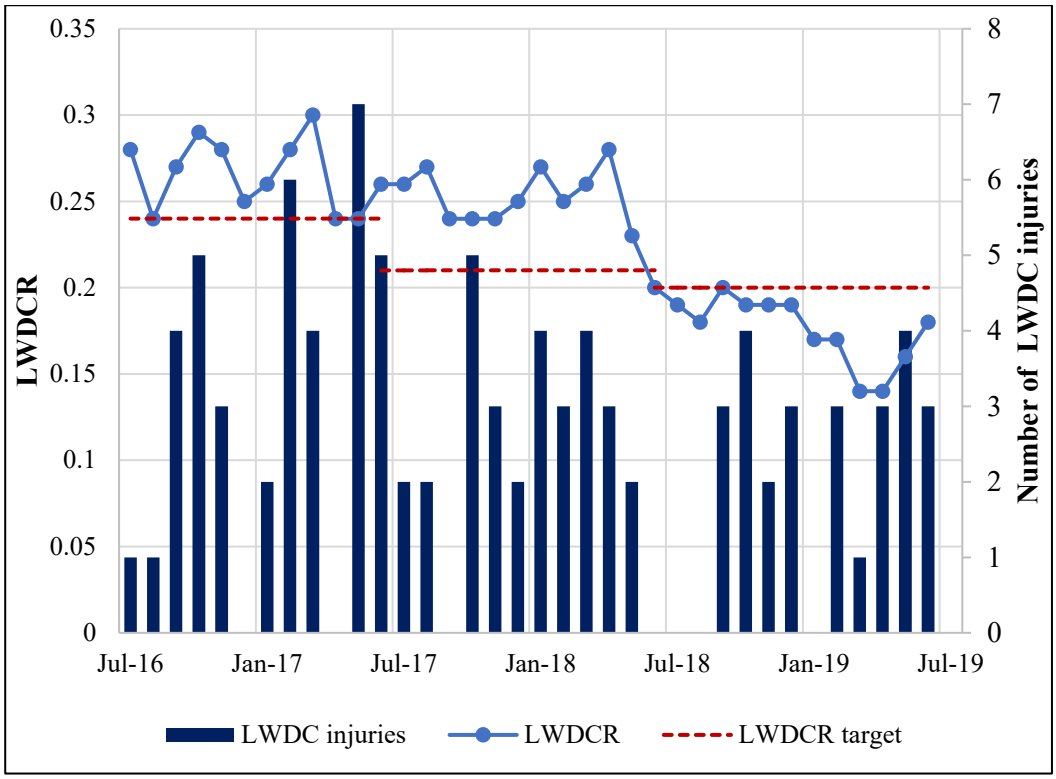


Figure 4-38: Company XYZ: Mining LWDCR FY16 - FY19

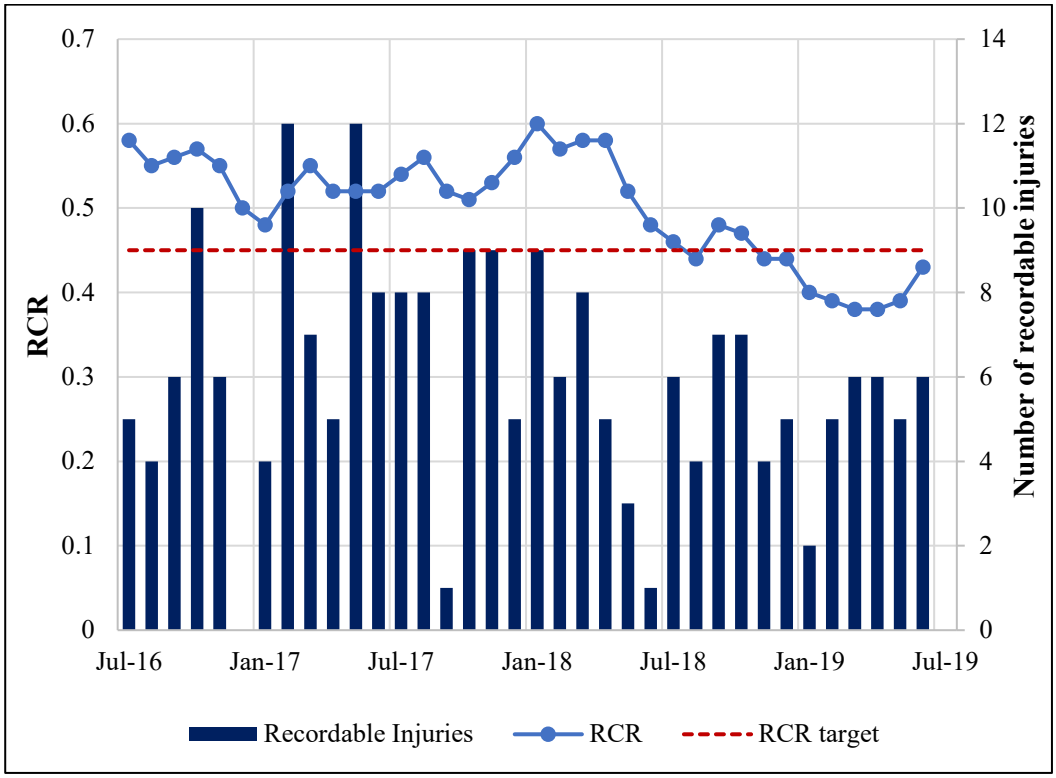


Figure 4-39: Company XYZ: Mining RCR FY16 - FY19

CHAPTER 5

5. DISCUSSION

5.1. INTRODUCTION

Chapter Five provides a discussion of the results presented in Chapter Four, in line with the research questions and objectives presented in Chapter One. The interpretation of these results is in line with the principles explicated in Chapter Two.

The discussion of the results is presented chronologically as presented in Chapter Four, to ensure consistency. The results of the statistical analysis of the survey response data, and their implications, are discussed in detail within this chapter, followed by an interpretation of the findings of the survey. The results of the incident investigation report analysis are then discussed in detail after which an in-depth discussion of the safety culture maturity assessment and safety KPI results is presented.

5.2. EMPLOYEE PERCEPTION SURVEY

5.2.1. Statistical analysis

The results of the normality tests indicated that the survey response data is highly leptokurtic with a large degree of negative skewness. These measures of kurtosis and skewness, together with a visual inspection of the distribution of the response data, indicate significant deviations from normal Gaussian distributions and hence the assumptions of parametric statistical tests are not fulfilled. This implies that non-parametric testing methods are necessary to provide meaningful statistical interpretation of the results obtained from the employee perception survey.

The reliability test, i.e. Cronbach's alpha obtained from SPSS, indicated a high level of data consistency with an alpha value of 0.929. This indicates the instrument is highly reliable and has high internal consistency. It is therefore possible to use all

the data obtained from the survey questionnaire to draw inferences on the safety perception of Company XYZ: Mining employees.

The mode and median of most of the individual question responses were “Strongly Agree” (5 points), except for the median of questions five and fourteen, which was “Agree” (4 points). This indicates there was consensus amongst employees relating to the perception of safety. A detailed analysis of the question responses per category is provided in the following section.

The non-parametric Kruskal Wallis test for association revealed there is an even distribution of question response across the 6 collieries. The null hypothesis used for the Kruskal Wallis test was the distribution of responses to each question, was the same across collieries, and the results obtained from SPSS showed low levels of significance across all questions indicating the null hypothesis should be retained.

The chosen test for measuring inter-item correlation was the Kendall tau B method. The results of this test indicate low correlation coefficient values which are indicative of low levels of correlation. The low correlation coefficients, therefore, suggest the responses of the questions were unique and there was no identified correlation between responses to each of the questions, from each respondent.

5.2.2. Participant Profile

The profile of the survey respondents was measured using two factors, namely; years of experience and mining colliery. No additional profiling data were collected to ensure the anonymity of the participants. An ideal participant profile would consist of equal numbers of respondents from each mining colliery and experience group, however, due to availability constraints, this was not set out as a requirement during the sample selection and survey process.

Employees of Colliery A constituted 46% of total responses and represents the largest colliery by the number of respondents. Colliery D and B contributed significantly to the number of responses and represent 25% and 19% of the total

responses, respectively. There is no concern with the representability of the data across all collieries, even though the colliery data has a significant bias, due to the results of the Kruskal Wallis test, which indicate the responses across collieries showed no major deviations.

The distribution of years of experience was considerably even, with no major bias observed. The majority of respondents fell within the '> 10 years' experience category (35%), and the '1 – 5 years' and '5 – 10 years' categories accounted for 28% and 27% respectively. The smallest group of respondents, according to years of experience, was the '< 1 year' experience group which was 10% of the total number of responses.

The participant profile was therefore varied enough to be deemed representative of the larger population group and this implies the ability to generalise the survey results to the target population.

5.2.3. Awareness of safety policies and regulations

The first section of the questionnaire comprised five questions, all relating to the respondents' awareness of the safety practices, policies and procedures as well as the emergency response and incident management principles relating to their line of work. These questions were as follows:

- I am aware of my departmental safety procedure
- I am informed of safety incidents and lessons learnt in a reasonable time
- I am familiar with safety laws that apply to my line of work
- I am regularly informed of safety hazards and safe work habits
- I am able to act in the event of an incident

The median response rate for the awareness segment of the survey was 'Strongly Agree' (5 points). The median percentage of respondents who responded, 'Strongly Agree' and 'Agree' to questions relating to awareness was 94%, indicating that the majority of employees have a good awareness of the safety policies and procedures of Company XYZ: Mining. Awareness and familiarity with the applicable

regulations, however, does not indicate the level of adherence to these rules, which is measured by the incident investigation data.

5.2.4. Commitment to Zero Harm

Company XYZ has an organisation-wide initiative, to achieve 'Zero Harm' by reducing all safety incidents to zero, across the business units. The mining business unit also aims to achieve 'Zero Harm' and the attitude of employees toward this concept was measured using four questions as follows:

- I believe zero harm is achievable
- Safety is my highest priority when performing any task
- I am mindful of my impact on workplace safety
- I am equipped with everything I need to work safely

The median response of the 'Zero Harm' questions was 'Strongly Agree' (5 points), which indicates a strong belief amongst employees that 'Zero Harm' is indeed possible and achievable. The median percentage of respondents that answered either 'Agree' or 'Strongly Agree' to the questions listed as 'Zero Harm' was 96%. This is indicative of a good safety culture and commitment of employees towards reducing the number of safety-related incidents to zero. It is also indicative of a high level of confidence in the safety management systems implemented by the leadership teams within the organisation.

5.2.5. Safety perception

Questions 10 through 14 assessed the employees' perception of the degree of safety within their work environments and job requirements. The safety perception was assessed using the following five questions:

- I believe safety is my responsibility
- I feel comfortable performing my duties in a safe work environment
- The safety of my colleague's matters to me
- I have been trained sufficiently to perform my job safely
- Our current safety program is sufficient to address all my concerns

The median response to the safety perception questions was also ‘Strongly Agree’ (5 points), indicating that employees generally feel safe when conducting the duties assigned to them. The median percentage of responses relating to ‘Agree’ and ‘Strongly Agree’, specifically relating to safety perception in the workplace was 96% which indicates that employees have no major issues with the ability to safely perform work tasks.

5.2.6. General comments

The comments provided by respondents were analysed and categorised according to 16 common themes identified in the responses. The primary areas of improvement identified by employees were ‘Safety Awareness’ and ‘Communication’ which accounted for 19% and 18% of the 107 comments received, respectively. Secondary areas of concern include ‘Safety training’, ‘Pressure from production targets’ and ‘Hazard Identification’, which accounted for 14%, 14% and 11% respectively. These comments provided valuable insight into the concerns of employees and their recommendations to ensure optimum safety performance. The open-ended nature of this question, allowed for respondents to provide unbiased views on improving safety performance. The categories highlighted in this section was, therefore, to be compared against the findings of the incident investigation report analysis, to identify common improvement areas.

The comments on safety training and communication are supported by observations made during the surveying process. There are significant linguistic barriers observed within the operator occupational group and major concerns with literacy that were highlighted when the survey responses were collected. All safety training conducted using computers, is conducted in English and requires the trainees to be able to read English at an intermediate level. These factors result in a decrease in the efficacy of safety training and communication relating to safety as the material may not be completely understood by the intended target audience.

A further concern identified during the surveying process was the organisation’s current restructuring which may affect the livelihoods of many employees. An unexpected bias may have been introduced into the survey results due to the timing

of this study, as employees are more likely to answer survey questions more honestly during normal business operations as opposed to during a turbulent restructuring process, even though complete anonymity was guaranteed.

5.3. INCIDENT INVESTIGATION ANALYSIS

5.3.1. Colliery distribution

The number of investigation reports analysed was largely from Collieries A and B, which together contributed to 46% of the 191 investigation reports analysed from FY17 to FY19. The smallest contribution was that of Colliery C, which accounted for 9% of the total reports analysed. This indicates that, on a risk-based approach, Colliery A and B, the focus of safety initiatives should primarily lie within these collieries and then further extended to the other collieries.

5.3.2. Distribution of occupational groups

The highest prevalence of occupational safety incidents was found within the 'Operators' group (approximately 48% of total incidents). This figure is in line with the assumptions made during the sample determination process for the employee perception survey, as the operators are exposed to the highest risk of occupational safety injury when compared with the other occupational group. The second and third largest occupation groups were 'General workers' and 'Artisans', which contributed to 13% and 12% respectively. This further narrows down the focus areas for the implementation of safety initiatives to operators initially, then to general workers and artisans and subsequently, to other occupational groups.

5.3.3. Incident classification

Occupational safety incidents are classified according to the severity of the injury sustained by employees. The highest occurrences of occupational safety incidents were noted in the LWDC, RWDC and FAC categories, accounting for 36%, 31% and 26% respectively, and combined, accounts for 93% of total incidents. There was a significant decrease in the number of LWDC and RWDC incidents over the fiscal years, however, an increase in the number of FAC incidents was noted from

FY18 to FY19. These observations are in line with the safety triangle illustrated by Kohler (2019), in which less significant incidents occur in larger numbers than incidents with higher impacts such as fatalities. A lack of effort to reduce the numbers of LWDC, RWDC and FAC incidents may lead to an increase in fatalities, however, the trend observed over the financial years shows a clear reduction in these incidents, thus suggesting the safety risk management measures being put in place are effective.

5.3.4. Number of years of experience

An analysis of the distribution of the number of incidents with years of experience was performed to identify possible issues of inexperienced employees or complacency (observed with employees with many years of experience). The results indicate an even distribution of incidents with experience, with employees in the '> 10 years' experience category accounting for a marginally higher contribution (25%) than employees with less than a year of experience (24%). The even distribution suggests that are no apparent issues with inexperience or complacency and that incidents have an equal probability of occurring with employees of varying work experience.

5.3.5. Incident time of day and day of week

The incident times and days may indicate issues with fatigue and tiredness, where incidents occur during early hours of the morning or late at night, and issues with lack of focus of employees, due to possible work during the weekends etc.

There was a large distribution of incidents around midday (11 am to 1 pm – 28%) and early morning (6 am – 6%). These peaks correspond with lunch hour, which occurs around noon, and start of shift which occurs around 6 am. The data suggests there may be a tendency of employees to lose focus just before, during and after their lunch breaks and additional measures are required to reduce these contributing factors. The start of shift period also exhibits a higher than 'normal' number of incidents and may be attributed to handover issues between shifts and/or possible delays in an employee's ability to gain focus at the beginning of the workday. The

morning peak in incidents may also indicate issues of employees losing focus at the end of shifts.

The largest occurrence of occupational safety incidents occurred between Mondays and Wednesdays. Incidents occurring on these three days of the week contribute to 67% of the total, with a significant reduction in incidents on Thursdays (16%) and Fridays (7%). Saturdays and Sundays accounted for 10% of the total incidents. There was a substantial reduction in the number of incidents occurring on every day of the week, from FY17 to FY19, except for Sundays which saw an increase of 4 incidents from FY18 to FY19. A large number of incidents during the workweek is expected due to a larger number of employees on-site as compared with the weekend. There was no significant difference observed between Mondays and Wednesdays (both 23%), which implies that employees returning to work after the weekend has no notable impact on the number of occupational safety-related incidents.

5.3.6. Bow-tie control failure analysis

The largest incidence of control failures was found to be administrative (78%) as opposed to the 22% engineering control failures. In general, the risk management process at Company XYZ: Mining are equally dependant on administrative controls (50%) and engineering controls (50%) however as per the observations of Zeiler, (2015), the hierarchy of hazard control deems administrative controls to be less effective than engineering controls.

The major administrative control failures observed, occurred with ‘Hazard Identification’ (15%), ‘Procedures and standards’ (13%), ‘Training and coaching’ (10%), ‘Supervision/leadership’ (9%), ‘Risk management’ (7%) and ‘Human behaviour’ (7%). There is clear alignment between the ‘Safety training’ and ‘Hazard Identification’ concerns raised by survey respondents and the results of the control failure prevalence analysis. The procedures and standards control failures, relate to the adherence to and the ability of procedures and standards to prevent incidents. There are concerns with the design and effectiveness of this control, which needs to be addressed to improve the number of control failures observed.

The human behaviour component featured in 7% of the occupational safety incidents from FY17 to FY19. There is a notable increase in the number of incidents relating to human behaviour from 13 in FY17 to 17 in FY18 and FY19. A decrease in the number of training and hazard identification related failures was observed from FY17 to FY19.

The engineering control failures observed were largely related to 'Design of machinery or equipment' (29%), 'Design of task or process' (22%) and management of change relating to modifications (MOC) (11%). The design of machinery or equipment control relates to the ability to use a piece of equipment to complete the task it was designed to be used, safely, without any unwanted consequences. The effectiveness of this control is therefore not to standard and requires intervention. The design of tasks or processes should be done following safety requirements, to ensure the task can be completed without injury to personnel or damage to assets. Incorrect process/task design was a contributing factor to 38 occupational safety incidents and represents incidents where employees had minimal ability to prevent incidents, due to incorrect design of the tasks they were working on. The management of change control is both an engineering control (relating to modifications) and administrative control (relating to the change management process). A total of 20 incidents listed incorrect/inadequate management of change when modifications were made.

The lack of or misuse of PPE only accounted for 11 incidents throughout the three years evaluated and does not represent a large proportion of incidents. Thus, it may be implied that employees are sufficiently trained in the appropriate use of PPE and minimal focus is required in this area.

A large number of administrative control failures, when compared with the engineering control failures, indicates the current ratio of 50:50 is not sufficient to successfully prevent incidents.

5.3.7. Contributing factors

There was a large degree of variability identified in the capturing of the organisational, workplace and personal factors, including multiple instances where the contributing factors were not identified at all. This introduced difficulty in being able to identify significant factors contributing to organisational, workplace and personal/team factors, which would provide insight into high prevalence areas of improvement.

The number of contributing factors that featured as organisational, workplace and personal, were approximately evenly distributed (243, 249 and 235 respectively) and hence no specific level of failures was observed to be more prevalent than another. This holds for variation in the contributing factor allocation over the three financial years assessed, hence there are no specific areas of concern in this regard.

5.3.8. Incident investigation report quality

The quality and completeness of incident investigations and reports may be used as lagging indicators of safety performance as these reports enable leadership teams to identify focus areas that are critical to the improvement of safety performance.

There has been a significant increase in the number of high-quality reports from FY17 (39%) to FY19 (60%), which include reports that have correctly identified barrier/control failures, contributing factors and learnings. There has also been an increase in low-quality reports, scored as 1 out of a possible 4 (indicating 3 missing elements), from 2% in FY17 to 4% in FY19. The largest element found to be incomplete in incident investigation reports was learnings derived from incidents. There has been a decrease in the number of reports that omit learnings from 28 in FY17 to 14 in FY19, however, this element is still the largest contributor (54%) of missing elements for FY19. Learnings are the most important tool available, which aids the correction of identified control failures, to prevent the recurrence of incidents and the occurrence of similar incidents within the organisation. The lack of learnings shared, thus puts the organisation at significant risk of repeat safety incidents, which are preventable.

5.4. SAFETY CULTURE MATURITY

The safety culture maturity assessment results indicate the mining division of Company XYZ lies within the compliant to proactive regions of maturity. The HSE performance factor lies within the mediocre range, and the HSE practices, therefore, performed better than the HSE performance.

The maturity assessment indicated there are excellent lagging indicators, however, these are tempered by weaker leading indicators of safety performance. There is therefore a concern with the sustainability of the lagging indicator performance over time. The governance, assurance, regulatory and reporting (GARR) element indicated high performance, however, these should be translated into the safety culture to ensure sustainable practices are well embedded in the workplace.

An additional focus area identified from the maturity assessment is the implementation and management of critical controls to improve HSE risk management and incident prevention.

5.5. SAFETY KEY PERFORMANCE INDICATORS (KPIS)

There have been noteworthy decreases in the two primary indicators of occupational safety performance. The RCR has seen a significant decrease from 0.58 at the beginning of FY17 to 0.43 at the end of FY19 against a fixed target of 0.45. The RCR reached a minimum value of 0.38 in March and April 2019 and showed an increase of 0.43 due to an increased number of recordable case injuries in May and June 2019. The LWDCR decreased significantly from the maximum value observed in FY17 (0.30 – target: 0.24) to 0.18 against a target of 0.20 observed at the end of FY19.

The reduction in the RCR and LWDCR indicates an overall improvement in safety performance, as observed with the analysis of the incident report data, and indicates the implementation of the high severity incident program (HSI) together with additional initiatives put in place by Company XYZ: Mining is effective and has aided in improving HSE performance.

CHAPTER 6

6. CONCLUSIONS AND RECOMMENDATIONS

6.1. INTRODUCTION

Chapter Six presents the conclusions that were drawn, based on the findings of this study and the discussion of the results, and is based on the primary data (survey) and secondary data (investigation reports, safety maturity assessment, and safety KPIs). The conclusions were drawn based on the sections presented within Chapter Four and Chapter Five and indicates how the study objectives were met.

6.2. CONCLUSIONS

6.2.1. Conclusions on employee safety perceptions

The awareness, Zero Harm and safety perception sections of the safety perception survey all indicate that employees are aware of the safety procedures applicable to their line of work and believe that zero harm is achievable. Employees also indicated they believe they work in a safe environment and are provided with sufficient tools and training to work safely.

The major concerns for employees are safety awareness, communication, hazard identification and safety training. There are additional concerns identified during the surveying process, which include language barriers and literacy rates. These are in alignment with the comments provided by employees on possible improvements to Company XYZ's safety management program.

6.2.2. Conclusions on incident investigation reporting

The quality of investigation reports is pivotal in reducing the number of incidents and consequently, improving the safety performance of Company XYZ: Mining. There are a significant number of reports that lack information on contributing factors, control failures and learnings to be shared with the mining team to prevent an incident recurrence.

There is a disproportionally high number of administrative control failures as opposed to engineering control failures when considering the 1:1 ratio of administrative and engineering controls. This indicates the organisation is highly reliant on administrative controls to prevent incidents and these administrative controls are not effective enough to manage occupational safety risks.

The primary group of employees identified in occupation safety incident investigation reports are mining operators. These employees face the highest risk in terms of occupational safety, due to their work environments and the nature of their occupation and this is accurately represented by the incident data.

There are peaks of incidents observed around the lunch break hour of mining employees as well as during change of shift in the morning (6 am). This is indicative of a cultural issue amongst employees, whereby the focus is not maintained during the abovementioned times of the day.

The contributing factors section of the incident reports contain a large degree of variation and as such, does not allow leadership to effectively identify high prevalence contributing factors within each level of identified causal factors.

6.2.3. Conclusions on maturity and Safety performance

The safety culture maturity assessment identified Company XYZ as being compliant to proactive with respect to HSE practices and mediocre with respect to HSE performance. A major contributor to the lower HSE performance as compared with practices stemmed from weaker leading indicators of performance. The mining business unit has a relatively high performing governance process; however, it is necessary to embed the safety policies and procedures into the organisational culture to ensure sustainable HSE performance.

The indicators of performance, RCR and LWDCR, show an overall improvement from FY17 to FY19, from operating above their respective targets to reductions below target. This is indicative of the efficacy of the HSI program in addition to other safety measures such as improvements in the reporting quality.

6.2.4. Conclusions on research objectives

The following objectives are expanded on, to illustrate how they were addressed by this study:

a) Evaluate the changes in Company XYZ mining safety KPIs before and post-implementation of the HSI program and assess the efficacy of the program
    - There has been a notable increase in safety performance observed from FY17 to FY19, indicating the HSI program has been successful in identifying and managing factors that affect safety performance. The HSI program began in FY16 and is continuously maturing since the initial conceptualisation and introduction of this program.

b) Determine the optimal combination of engineering and administrative controls on bow-ties to effectively manage safety risks
    - The current ratio of engineering controls to administrative controls was identified to be 1:1. The ratio of engineering to administrative control failures was determined to be 1:3.62, indicating that administrative controls were 3.62 times more likely to fail than engineering controls. It is proposed to increase the number of engineering controls to address the top 6 administrative control failures, thus changing the original ratio to approximately 1.12:1. This is the minimum suggested ratio and increasing the number of engineering controls above this ratio will prove to be effective in addressing the high number of safety incidents.

c) Investigate and analyse the possible relationships between RCA root cause distributions and behaviour transformation initiative implementation to identify clusters of root causes and associated levels
    - The quality of root cause analysis reports hindered the ability to access the contributing factor levels at the required granularity to provide insight into the levels of root cause occurrence. The number of factors identified at each level (organisational, workplace and personal) was found to be equal, before and during the

implementation of the HSI program which indicates the program has minimal effect on the level of contributing factors to the root causes.

d) Evaluate the safety maturity of the mining business unit and provide suitable recommendations to improve safety maturity
    - The organisation's safety maturity level was identified as compliant to proactive, with a greater performance observed in HSE practices as opposed to HSE performance. The results of the maturity assessment indicate that stronger focus needs to be placed on leading indicators of performance and on embedding safety practices into the organisation's culture to shift the organisational safety maturity to the proactive region.

6.3. RECOMMENDATIONS

6.3.1. Recommendations on employee safety perception

This study confirmed the front-line workers of Company XYZ: Mining have a good understanding of applicable safety requirements and believe the organisation has provided them with the required tools to perform their tasks safely. They have highlighted key focus areas, such as training and communication which are improvement opportunities for the business to ensure safer operations. It is recommended that linguistic and communication specialists are consulted to identify optimisation opportunities in the current safety program. It is further recommended the organisation finds alternative ways, possibly in various languages that are prevalent amongst these employees, to effectively communicate learnings and new processes and procedures. The training facilities, especially, the English based computer training, should be tailored to provide training in other languages as well.

There is a definite need to improve literacy rates amongst employees and the effect of low literacy rates on the ability to understand the fundamentals being presented during safety training and technical training sessions needs to be further investigated, and appropriate measures put in place to ensure that literacy is not a barrier to working safely.

In addition to the efficacy of communication, some employees suggested more training, both safety and technical, to improve their ability to perform their duties without unintended consequences such as occupational injuries. It is recommended the training program and the frequency of training be reviewed, with input from both learning specialists and employees to find a suitable balance between operational requirements and employee requirements.

An additional recommendation is to review the number of employees required per shift, to address concerns from employees that production targets are too high and require them to work quickly, which sometimes compromises their ability to identify hazards effectively and hence work safely.

6.3.2. Recommendations on incident investigations and reporting

There was major variation observed in the reporting structure and quality between the mining collieries. It is recommended that a standard approach to the RCA process is developed for the mining business unit, that caters to the needs of all the individual collieries and allows for comparative analyses of incident data across the mining business. Personnel and teams responsible for the incident investigation process should be trained adequately to improve incident investigation reporting quality, and an assurance process should be put in place to allow for internal auditing of incident reports to ensure the quality standards are being met, regularly.

The business should look at possible technological solutions, such as SharePoint lists, to better manage the incident records. The use of technological tools will also aid in the standardisation of reporting, and better incident report management.

6.3.3. Recommendations on safety culture maturity and safety KPIs

The mining division was found to be compliant to proactive on safety policies and mediocre of safety performance. It is recommended that an in-depth study is performed on developing a suite of leading indicators to further improve the HSE performance of the business. A task team should be set up to explore industry best practice regarding leading indicators and the management thereof. The quality of

the incident reporting process is a possible starting point for leading indicators, as well as the timely and effective communication of learnings to mining personnel.

The lagging indicators of performance have shown a significant decrease, due to a decrease in the number of recordable injuries. This indicates the HSI program, and the initiatives being individually implemented within this program, has positively influenced safety performance. The number of behaviour related incidents have shown a steady decline over the past 3 fiscal years. The behavioural aspect of safety performance is an umbrella term, consisting of various constituents of which training and competency, awareness and perception are included. The recommended way to address behavioural transformation issues is to address the underlying factors that need to be adequately managed. The results of this study suggest the development of a safety management framework, in which the abovementioned target areas can be addressed and may be prioritised using a risk-based approach. This framework should be reviewed regularly and amended where necessary, using live occupational safety data to inform this process.

6.3.4. Recommendations to academia for future research

There has been minimal research into the detailed drivers of HSE performance and specific occupational safety performance in the mining industry in South Africa. This research was limited to Company XYZ's mining division, however, there is an opportunity to expand the data set to an industry-wide study, which allows for identification of commonalities across the mining industry, and transfer of best practice between mining companies.

There also exists an opportunity to expand the study scope to more business units within Company XYZ, however, it is to be noted that mining safety is highly specialised and requires specific interventions, not as prevalent in the other business units of Company XYZ. There is a definite benefit, however, in adapting principles found in other parts of the organisation to the mining environment, to improve the overall aggregated safety culture maturity of Company XYZ. Further research should therefore be conducted on Company XYZ's safety performance and variations across the various operating entities within the business.

The sample size calculated for this research study is larger than the minimum required sample had a convergence sample size been used. It is recommended that a minimum sample size calculation be investigated to ensure efficiency for future research studies.

There is an expanding need for more research in the field of the use of artificial intelligence in HSE management systems, as the world currently experience the 4th industrial revolution and as the need for sustainable operations increases exponentially. Research should therefore be conducted in the field of data science and artificial intelligence, and the ability to develop predictive models for safety performance.

6.3.5. Limitations of the research

- The scope of the research instrument, i.e. the employee safety perception survey was limited to operators and foremen and respondents were selected based on availability. The sample size and population excluded all other occupational groups such as artisans, general workers, support services and leadership teams
- The variables measured in the primary data source were purely qualitative
- Only formal incident investigation reports relating to occupational safety incidents were analysed (as secondary data), all informal investigation reports were excluded
- The incident investigation data were obtained for the period FY17 – FY19, all other fiscal years were not included in the scope of this research
- Only occupational safety data were considered in this study, no occupational health, process safety, environmental and other HSE related data was considered
- Company XYZ's mining division was the only entity considered in this study and all other business units and operating entities within Company XYZ were excluded

6.4. FINAL REMARKS

An organisations safety performance is critical not only due to regulations and associated legal implications but due to the knock-on effects on productivity and the business from a financial perspective as well. It is therefore imperative that organisations such as Company XYZ and other organisations in the mining industry manage safety as effectively and efficiently as possible. The contributions of employees should not be underestimated in the development of safety procedures and safety risk management programs. The development and implementation of safety initiatives should therefore include both top-down and bottom-up consultations to ensure the programs are well informed and are appropriate to manage safety.

The HSI program has definitive positive impacts on the safety performance of Company XYZ: Mining, however, this study has identified several opportunities for optimisation of the program, to further enhance its positive impact on safety performance. Company XYZ should consider investigating the various recommendations put forward in this research report, to optimise the current safety initiatives.

This study has provided factual evidence on the multiple contributing factors that affect the safety performance of Company XYZ: Mining and recommends the organisation incorporate the findings into their short, medium and long-term planning.

CHAPTER 7

7. REFERENCES

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CHAPTER 8

8. APPENDICES

8.1. APPENDIX A: PARTICIPANT INFORMATION SHEET

Participant Information Sheet

20 September 2020

Dear Vice President: SHE,

Re: Participation in Research on *the impact of behavioural transformation initiatives on occupational safety performance in the Company XYZ: Mining environment in South Africa*

I am a part-time MSc student in the School of Mechanical, Industrial and Aeronautical Engineering at the University of the Witwatersrand, under the supervision of Mrs Lorrainne Doherty. My MSc title is ***The impact of behavioural transformation initiatives on occupational safety performance at Company XYZ: Mining environment in South Africa***.

I believe that there are multiple opportunities to gain insight into and improve the current occupational safety performance at Company XYZ: Mining. I would specifically like to understand the role that the behavioural aspects of the HSI have impacted the occupational safety performance at Company XYZ: Mining and how the risk management program can be optimized to further improve occupational safety Key Performance Indicators (KPI)

I would like to formally invite you to participate in this study. As a Manager of the well-established integrated Energy and Chemicals business, your knowledge and experience would contribute significantly.

The study will be conducted in March 2021. Involvement in the study would entail 250 mining operator surveys as well as secondary data obtained from Company XYZ. The surveys will be used to determine the safety perception of front line workers. This research project will also require the study of incident root cause analysis results, specifically relating to occupational safety incidents as well as risk management bow-ties relating to occupational safety at Company XYZ: Mining.

Participation in the study is voluntary, and you may withdraw at any time. Anonymity (regarding any manager/employee names as well as information relating to safety-related incidents and related reports) and confidentiality of information provided will be assured and respected.

The results of the study will form part of my MSc dissertation report, and may also be reported in academic papers and at conferences. A summary of the results of the research will be made available to you on request.

Please contact me if you have any questions regarding the research and participation in the study.

I look forward to hearing from you.

Yours faithfully,

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8.2. APPENDIX B: LETTER OF CONSENT

Letter of Consent

Dear Participant,

Thank you for accepting to participate in this study. Please complete this consent form as you see appropriate. By signing this consent form, you are indicating that you have read and understood the description of this study and that you agree to the terms as described below:

	Mark with **X**	
	YES	NO
I confirm that I have read and understood the information about this study as provided in the participant's information sheet.		
I understand that my participation is voluntary and that I am free to withdraw at any time without any penalties or negative consequences against me.		
I grant permission for the interview to be audio recorded.		
I agree that the information I provide may be treated as strictly confidential and anonymous and only the research team will have access to the interview data.		
I understand that the information acquired from the interview will not be recorded in excess of what is required for this study.		
I agree that the results of this study may be recorded in academic journals and at conferences.		
I have had the opportunity to ask any questions related to this study and I have had all my questions answered to my satisfaction.		
I may request a report summary, which will come as a result of this study.		

With full knowledge of all the above-mentioned terms, I agree to participate in this study.

Participant		Consent taken by (Researcher)	
Name		Name	Keegan Devraj
Signature		Signature	
Date		Date	*15 March 2021*

8.3. APPENDIX C: COMPANY XYZ PERMISSION LETTER

Request for permission to use Company XYZ High Severity Incident and risk management data for Masters Research Project (MSc Engineering Management)

Dear Vice President SHE,

I am currently pursuing a Master's Degree (MSc) in Engineering Management through the University of the Witwatersrand. The requirements of the abovementioned degree include the completion of a research report. The research topic I have chosen to investigate is: ***"The impact of behavioural transformation initiatives on occupational safety performance in the Company XYZ: Mining environment in South Africa"***, under the supervision of Mrs Lorrainne Doherty.

The research objectives of this research project are as follows:

- Evaluate the changes in Company XYZ mining safety KPIs before and post-implementation of the HSI program
- Determine the optimal combination of engineering and administrative controls on bow-ties to effectively manage safety risks
- Investigate and analyse the possible relationships between RCA root cause distributions and behaviour transformation initiative implementation
- Evaluate the safety maturity of the mining business unit

The source data required to complete this research include the following:

- Company XYZ Group 1 SHE Excellence Approach procedure
- Company XYZ Group High Severity Incident statistics (i.e. number of each category of incidents per business unit over past four fiscal years)
- Company XYZ Group and Company XYZ Mining bow-ties and performance criteria (where available)
- Company XYZ Mining root cause analysis (RCA) reports and incident reports
- Company XYZ Mining safety culture maturity assessment/s
- Company XYZ Mining employee perception survey results

Confidentiality and security

The following measures will be put in place to ensure data confidentiality and security:

- All Company XYZ data will be stored on a password protected Company XYZ-owned laptop
- No source data will be shared with external parties
- The use of any employee-related information or information that may lead to the identification of Company XYZ employees will be strictly prohibited
- Incident report and RCA data will be used to identify control failure prevalence and to identify possible shifts in root cause levels – no individual incident details will be disclosed to third parties
- Survey questionnaires will be conducted anonymously (i.e. participants details will not be captured as part of this research)

Upon completion of this research project, a copy will be handed to the relevant stakeholders within Company XYZ. Permission to conduct this study will be greatly appreciated, considering the benefit this work may have on Company XYZ's safety performance.

I have provided my contact details as well as my supervisor's contact details below, should any further information or clarification be required.

Keegan Devraj
MSc Engineering Management
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8.4. APPENDIX D: ETHICAL CLEARANCE

UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG

SCHOOL OF MECHANICAL, INDUSTRIAL AND AERONAUTIAL ENG. ETHICS COMMITTEE
CONSTITUTED UNDER THE UNIVERSITY HUMAN RESEARCH ETHICS COMMITTEE (NON-MEDICAL)

CLEARANCE CERTIFICATE	**PROTOCOL NUMBER: MIAEC 110/20**
PROJECT TITLE	The impact of behavioural transformation initiatives on occupational safety performance in the Company XYZ Mining environment in South Africa
INVESTIGATOR	Mr Keegan Devraj
SCHOOL/DEPARTMENT OF INVESTIGATOR	Mechanical, Industrial and Aeronautical Engineering
DATE CONSIDERED	1 October 2020
DECISION OF THE COMMITTEE	Approved unconditionally
EXPIRY DATE	Date of submission of the project report

ISSUE DATE OF CERTIFICATE 19 November 2020 **CHAIRPERSON** _____
(Dr. Emwanu)

cc: Supervisor : Mrs. Lorrainne Doherty

DECLARATION OF INVESTIGATOR

To be completed in duplicate and **ONE COPY** returned to the Chairperson of the School/Department ethics committee.

I fully understand the conditions under which I am are authorized to carry out the abovementioned research and I guarantee to ensure compliance with these conditions. Should any departure to be contemplated from the research procedure as approved I/we undertake to resubmit the protocol to the Committee.

_____ 19 / 11 / 2020
Signature **Date**

8.5. APPENDIX E: EMPLOYEE SAFETY PERCEPTION SURVEY

EMPLOYEE SAFETY PERCEPTION SURVEY

a	Colliery	

b	Number of years of experience:	< 1 year	
		1 - 5 years	
		5 - 10 years	
		> 10 years	

Mark relevant answer with an X		Strongly Agree	Agree	Neither agree nor disagree	Disagree	Strongly disagree
		5	4	3	2	1
Awareness						
1	I am aware of my departmental safety procedure					
2	I am informed of safety incidents and lessons learnt in a reasonable time					
3	I am familiar with safety laws that apply to my line of work					
4	I am regularly informed of safety hazards and safe work habits					
5	I am able to act in the event of an incident					
Zero Harm						
6	I believe zero harm is achievable					
7	Safety is my highest priority when performing any task					
8	I am mindful of my impact on workplace safety					
9	I am equipped with everything I need to work safely					
Safety perception						
10	I believe safety is my responsibility					
11	I feel comfortable performing my duties in a safe work environment					
12	The safety of my colleagues matter to me					
13	I have been trained sufficiently to perform my job safely					
14	Our current safety program is sufficient to address all my concerns					

c	In general, what do you think can be done to improve workplace safety?	

8.6. APPENDIX F: SURVEY RESPONSES

Table F- 1: Employee perception survey response data

				Section													
				Awareness					Zero Harm					Safety perception			
Response	**Colliery**	**Experience**	**General Comments**	**Q1**	**Q2**	**Q3**	**Q4**	**Q5**	**Q6**	**Q7**	**Q8**	**Q9**	**Q10**	**Q11**	**Q12**	**Q13**	**Q14**
1		2 - 5 years	Managers build better relationships with operators so they can be comfortable while they are around	5	5	5	5	4	5	5	5	4	5	5	5	4	5
2		> 10 years	Not putting too much pressure in terms of breakdown cos that turns to overlook safety and focus on production	4	4	4	4	4	4	4	4	4	5	4	5	4	4
3		> 10 years	0	4	4	4	4	4	4	4	4	4	4	2	4	2	2
4		2 - 5 years	We are doing well	5	4	5	5	4	5	5	5	5	5	5	5	5	5
5		> 10 years	When new systems are introduced it is important we have put in on test to determine if it works or needs adjustment	5	5	5	5	5	5	5	5	5	5	5	5	5	5
6		5 - 10 years	0	4	4	4	4	4	5	4	5	4	5	4	5	5	4
7		2 - 5 years	0	4	3	4	4	4	5	4	4	3	5	5	4	4	3
8		> 10 years	0	4	4	4	4	4	4	5	5	4	5	4	5	4	4

				Section													
				Awareness					Zero Harm				Safety perception				
9		2 - 5 years	0	5	5	4	5	4	5	5	5	5	5	4	5	5	5
10		2 - 5 years	Create a culture where safety is priority and change mindset	5	5	5	5	4	5	4	4	4	5	5	5	4	3
11		> 10 years	Remain mindful of your environment at all times when performing your duties	5	4	4	5	4	3	3	5	4	5	4	5	5	4
12		> 10 years	Less paperwork and more focus on safety and production	5	4	4	5	4	3	5	4	3	5	4	5	3	3
13		> 10 years	I think we must not fall behind on the fourth industrial revolution meaning the way we receive information must be current and understandable	5	5	5	5	5	5	4	5	5	5	5	5	5	5
14		5 - 10 years	We need to be trained regularly	5	5	5	5	5	5	5	5	5	5	5	5	5	4
15		< 1 year	Safety training should be done more often in order to remind employees all the time. Attitude towards our supervisor should change when it comes to safety of employees all the time	5	5	5	5	5	5	5	5	5	5	5	5	5	5
16		5 - 10 years	0	4	4	4	1	2	5	5	4	2	5	5	5	4	2

				Section													
				Awareness					Zero Harm				Safety perception				
17		2 - 5 years	They must engage with the workers	4	5	3	5	4	4	4	4	5	5	4	5	4	4
18		2 - 5 years	We be better communication as a team	4	4	4	4	4	4	4	4	4	4	4	4	5	5
19		< 1 year	Make sure we perform all safety precaution and make sure we remove all hazardous equipment away from our work place	4	4	4	5	4	5	5	4	4	5	5	5	5	4
20		2 - 5 years	By doing proper MOSH in our work place	5	5	5	5	5	5	5	5	5	5	5	5	5	5
21		5 - 10 years	0	5	4	4	5	4	5	4	5	5	4	4	4	4	5
22		< 1 year	Stop, look, access, manage	5	5	4	5	4	4	5	4	4	5	5	5	5	4
23		5 - 10 years	0	4	4	4	4	4	4	4	4	4	4	4	4	4	4
24		5 - 10 years	0	5	4	4	4	5	4	5	5	4	5	3	4	3	4
25		2 - 5 years	Motivation to workers in case of bonuses	5	5	5	5	5	5	5	5	5	5	5	5	5	5
26		> 10 years	Communicate support from shift boss	3	3	4	3	3	3	4	4	3	4	3	4	3	3
27		2 - 5 years	0	5	4	4	5	4	4	5	5	5	5	5	4	5	4
28		> 10 years	0	5	5	5	5	4	5	5	5	5	5	5	5	5	5
29		5 - 10 years	0	4	4	4	4	5	4	5	4	3	4	4	4	4	4

				Section													
				Awareness					Zero Harm				Safety perception				
30		2 - 5 years	We all need to do safety course so that we can get more information about safety	5	5	5	5	5	5	5	5	4	5	5	5	5	5
31		5 - 10 years	0	5	5	5	5	5	5	5	5	5	5	5	5	5	5
32		5 - 10 years	0	5	5	5	5	5	5	5	5	5	5	5	5	5	5
33		< 1 year	0	5	5	5	5	5	5	5	5	5	5	5	5	5	5
34		5 - 10 years	Give us enough time to do our job safely. Good communication at our time.	5	4	5	5	4	5	5	5	5	5	4	5	5	5
35		> 10 years	0	5	5	5	5	5	5	5	5	5	5	5	5	5	5
36		< 1 year	0	5	4	4	3	4	4	4	4	4	5	4	5	4	3
37		2 - 5 years	To make sure working safety and do a SLAM before you act	5	5	5	5	5	5	5	5	5	5	5	5	5	5
38		2 - 5 years	Everybody to be trained	4	4	4	4	4	4	4	4	5	5	5	5	4	4
39		> 10 years	Must take safe first before coal	5	5	4	4	4	4	1	4	1	4	5	4	5	4
40		2 - 5 years	0	4	5	5	4	4	5	5	5	5	4	5	5	5	5
41		> 10 years	0	5	5	5	5	5	5	5	5	5	5	5	5	5	5
42		5 - 10 years	0	5	5	5	5	5	5	5	4	4	5	5	5	5	5
43		5 - 10 years	0	4	3	5	4	2	2	4	1	5	5	1	2	3	2
44		5 - 10 years	Coaching and training with positive and gentle way	4	4	4	4	3	4	4	4	4	4	4	4	3	3

				Section														
				Awareness					Zero Harm					Safety perception				
45		5 - 10 years	0	4	5	5	4	4	5	5	4	3	4	4	4	4	4
46		2 - 5 years	More of safety training	5	5	5	5	5	5	5	5	5	5	5	5	5	5
47		2 - 5 years	0	4	4	4	4	4	4	4	4	4	4	4	4	4	4
48		> 10 years	0	5	5	5	4	5	4	5	5	4	4	5	5	5	4
49		> 10 years	0	4	4	4	4	4	4	5	4	4	4	4	5	4	4
50		2 - 5 years	0	5	5	5	5	5	5	5	5	5	5	5	5	5	5
51		5 - 10 years	To perform SLAM so we can do better	4	4	4	4	4	4	4	4	4	4	4	4	4	4
52		2 - 5 years	To perform SLAM in everything we do	4	4	4	4	4	4	4	4	4	4	4	4	4	4
53		> 10 years	0	5	4	5	5	5	5	5	4	5	5	5	5	5	5
54		< 1 year	0	5	5	5	5	5	5	5	5	5	5	5	5	5	5
55		< 1 year	Everyone must concentrate when it comes to work	5	5	5	5	5	5	5	5	5	5	5	5	5	5
56		2 - 5 years	0	5	4	5	5	5	5	5	5	4	5	5	5	5	3
57		< 1 year	0	4	4	4	4	4	4	4	4	4	4	4	4	4	4
58		> 10 years	0	5	5	5	5	5	5	5	5	5	5	5	5	5	5
59		< 1 year	0	5	5	5	5	5	5	5	5	5	5	5	5	5	5
60		> 10 years	Poor planning	4	5	5	5	5	5	4	4	4	5	5	5	5	5
61		5 - 10 years	0	2	1	1	1	2	1	1	1	1	1	1	1	1	1

				Section													
				Awareness					Zero Harm				Safety perception				
62		< 1 year	To always ensure that we follow safety in each and every task. To also SLAM before doing a job	5	4	5	5	4	5	5	5	3	5	4	5	4	4
63		5 - 10 years	0	5	5	5	5	5	5	5	5	5	5	5	5	5	5
64		> 10 years	Good planning must apply. Really ask the people	5	5	5	5	4	5	5	5	4	5	5	5	5	4
65		< 1 year	0	5	5	5	5	5	5	5	5	5	5	5	5	5	5
66		< 1 year	Need good performance to achieve people	4	3	3	4	3	4	4	4	4	4	4	4	4	4
67		2 - 5 years	0	4	4	5	3	5	4	4	5	3	4	5	4	4	5
68		2 - 5 years	To have safety topics every day in working place	4	4	4	4	4	5	4	4	4	5	4	4	4	4
69		5 - 10 years	I think this FULCO will help us to work safely and achieve Zero Harm in the future	5	5	5	5	5	5	5	5	4	4	5	4	5	4
70		2 - 5 years	0	4	4	5	4	4	5	5	5	5	5	5	4	5	4
71		5 - 10 years	I think they must tell us always about the problem. Sometimes they tell us after and change detail. Issues with pay	4	4	4	3	3	5	5	4	4	5	4	5	3	4
72		> 10 years	0	3	5	5	4	4	5	5	4	5	5	5	4	5	5

				Section														
				Awareness					Zero Harm					Safety perception				
73		> 10 years	Give employee sufficient training to perform their task	5	4	4	4	5	5	5	4	4	5	4	5	3	4
74		2 - 5 years	Always inform of the hazards	5	5	5	5	4	4	5	4	3	5	5	5	4	4
75		> 10 years	Safe topic must be a way of life before we start our shift	5	5	5	5	5	5	5	5	5	5	5	5	5	5
76		> 10 years	Always provided with full PPE	5	5	5	5	4	5	5	5	4	5	5	5	5	5
77		5 - 10 years	Everything is clear	4	4	4	4	4	4	4	4	4	4	4	4	4	4
78		5 - 10 years	Follow safety rules	5	5	5	4	4	4	5	5	5	5	4	5	5	4
79		5 - 10 years	0	4	4	4	5	4	4	5	4	4	5	5	5	5	5
80		5 - 10 years	Training quarterly	5	4	5	3	5	4	5	4	3	5	5	4	5	3
81		> 10 years	0	1	5	5	5	5	5	3	5	5	5	5	5	5	5
82		5 - 10 years	Communication	3	3	4	4	3	3	3	3	3	2	2	3	4	3
83		> 10 years	To motivate the workers and give them a morale	5	5	5	5	4	5	5	5	5	5	5	5	4	5
84		> 10 years	0	4	4	5	4	5	5	5	4	5	5	4	4	5	4
85		> 10 years	0	5	5	5	5	5	5	5	5	5	5	5	5	5	5
86		> 10 years	Workers must be given space not to be pressurized during break hours	4	5	5	5	5	3	4	5	5	4	5	5	5	4
87		> 10 years	Continue to constantly remind us of the importance of safety	5	5	5	5	5	5	5	5	5	5	5	5	5	5

				Section														
				Awareness					Zero Harm				Safety perception					
88		< 1 year	More training	4	4	4	4	4	4	5	5	4	5	5	5	4	5
89		> 10 years	To give the correct training, I don't work in sections but I must answer questions that is not relevant to my work environment	5	5	5	5	5	5	5	5	5	5	5	5	5	2
90		5 - 10 years	Safety comes first thus why we must do SLAM before we do job	4	4	4	5	4	4	5	4	4	5	5	4	5	5
91		< 1 year	0	5	5	5	5	5	5	5	5	5	5	5	5	5	5
92		2 - 5 years	0	5	5	5	5	4	5	5	5	5	4	5	5	5	5
93		2 - 5 years	0	5	5	5	5	4	4	5	5	5	5	5	5	5	4
94		2 - 5 years	0	4	5	4	4	4	5	4	4	4	4	4	4	4	4
95		2 - 5 years	0	4	5	4	4	4	5	5	4	5	5	5	2	5	4
96		< 1 year	0	5	5	5	5	5	4	5	5	5	5	5	5	5	5
97		5 - 10 years	Retrain the employees	5	5	5	5	5	5	5	5	5	5	5	5	5	5
98		2 - 5 years	0	5	5	5	5	5	5	5	5	5	5	5	5	5	5
99		5 - 10 years	0	5	5	5	5	4	5	5	5	3	4	5	5	5	5
100		2 - 5 years	Good	5	5	5	5	5	5	4	5	5	5	5	5	5	5
101		2 - 5 years	0	4	4	3	4	3	4	5	4	4	5	5	5	5	5
102		5 - 10 years	Do more work training	4	4	4	4	4	5	5	5	5	5	5	5	5	5

				Section														
				Awareness					Zero Harm					Safety perception				
103		2 - 5 years	Communicate with each other and do SLAM all the time	4	5	4	4	4	5	5	5	4	5	5	5	4	5
104		> 10 years	0	5	5	5	5	5	5	5	5	5	5	5	5	5	5
105		> 10 years	0	5	4	4	4	4	4	5	4	4	5	4	5	4	4
106		2 - 5 years	0	5	5	5	5	5	4	5	5	5	5	5	5	5	5
107		2 - 5 years	Always have safety meetings to share our problems we are facing	5	5	5	5	4	5	5	5	5	5	5	5	5	5
108		2 - 5 years	0	4	4	4	4	4	4	4	4	4	4	4	4	4	4
109		2 - 5 years	To work as a team all the time	5	5	5	5	5	5	5	5	5	5	5	5	5	1
110		2 - 5 years	Management should give a chance to employees to work safe instead of putting too much pressure on workers	5	5	4	4	1	5	5	5	4	5	5	5	4	3
111		2 - 5 years	Better communication in situations where dangerous work is to be done and there is a lack of necessary safety equipment available	4	3	4	2	5	5	5	4	3	5	5	5	4	4
112		2 - 5 years	Better system to working at high or underground equipment	4	5	4	5	3	5	5	5	3	5	5	5	5	4
113		> 10 years	0	5	4	4	5	4	5	5	4	4	5	4	4	4	4
114		5 - 10 years	I am happy thanks	4	5	4	4	5	4	4	5	4	5	5	5	5	5

				Section														
				Awareness					Zero Harm				Safety perception					
115		2 - 5 years	More training could help a lot	5	5	5	5	5	5	5	5	4	5	5	5	4	4
116		5 - 10 years	0	5	5	4	5	4	4	5	5	4	5	5	5	5	4
117		5 - 10 years	0	5	5	5	5	4	5	5	5	5	5	5	5	5	5
118		> 10 years	The safety of my colleagues matters to me	5	5	5	5	5	5	5	5	5	5	5	5	5	5
119		2 - 5 years	Everyone commits safety during working hours	5	5	3	5	5	5	5	5	5	5	5	5	5	5
120		2 - 5 years	Following the procedure	5	5	5	5	5	5	5	5	5	5	5	5	5	5
121		2 - 5 years	To follow safety rules and learn more and get to learn about it	5	5	5	5	5	5	5	5	5	5	5	5	5	5
122		2 - 5 years	0	4	4	4	4	4	4	4	4	4	4	4	4	4	4
123		2 - 5 years	0	5	5	5	5	4	4	4	4	4	5	5	5	5	5
124		2 - 5 years	0	5	4	4	5	5	5	5	3	5	5	5	5	5	5
125		> 10 years	Working as a team and also management must consider our opinions	4	4	4	4	4	4	4	4	4	4	4	4	4	4
126		2 - 5 years	Reduce sections target and employee salary increase	4	4	4	4	4	4	4	4	4	4	4	4	4	4
127		2 - 5 years	Making sure that safety procedures are looked every time when people are performing a job	5	5	5	5	4	5	5	5	5	5	5	4	5	5

				Section														
				Awareness					Zero Harm				Safety perception					
128		5 - 10 years	The company must focus on training more people regarding safety	5	4	5	5	5	5	5	5	4	5	5	5	5	5
129		5 - 10 years	Be aware of hazards all the time	4	4	4	5	5	5	5	5	4	5	5	5	5	4
130		> 10 years	0	4	5	5	4	4	4	5	4	4	5	5	5	5	5
131		> 10 years	Daily safety communication to all	4	4	4	4	3	4	5	4	3	5	5	4	4	4
132		> 10 years	Teamwork and communication	5	5	5	5	5	5	5	5	5	5	5	5	5	5
133		> 10 years	Every person is responsible for their own safety. Attitude towards safety can be a challenge	5	5	5	5	5	5	5	5	5	5	5	5	5	5
134		> 10 years	0	5	4	4	4	4	4	4	4	4	4	4	4	4	4
135		> 10 years	0	4	4	4	4	4	4	4	4	4	4	4	4	4	4
136		5 - 10 years	Is to reduce the production targets so that the employees will not work under pressure	5	5	5	5	5	5	5	5	5	5	5	5	5	5
137		> 10 years	0	5	4	5	4	4	5	4	4	4	5	4	4	4	4
138		5 - 10 years	Work safely and take care of my job	1	2	2	4	5	5	5	5	5	5	5	4	5	5
139		2 - 5 years	0	5	5	5	5	5	5	5	5	5	5	5	5	5	5
140		2 - 5 years	0	4	4	5	4	4	5	4	4	4	5	5	5	5	4

				Section														
				Awareness					Zero Harm				Safety perception					
141		> 10 years	Let’s practice what we preach	5	5	5	5	5	4	5	5	4	5	5	5	5	5
142		5 - 10 years	0	4	4	4	4	4	5	5	4	5	5	4	4	4	4
143		> 10 years	0	5	5	4	5	5	5	5	5	5	5	5	5	5	5	5
144		5 - 10 years	0	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
145		5 - 10 years	Focus more on control room safety	5	5	3	5	5	5	5	5	5	5	5	5	5	5	5
146		5 - 10 years	0	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
147		> 10 years	0	5	5	5	5	4	4	4	4	4	4	4	4	4	4	4
148		5 - 10 years	0	4	4	4	4	4	4	4	4	4	5	4	5	4	4	4
149		> 10 years	More training courses and refresher course	5	5	5	5	5	4	5	5	5	5	5	5	4	4	4
150		2 - 5 years	Allow employees to work in their own and do not rush	5	4	5	5	5	5	5	5	5	5	5	5	5	5	5
151		5 - 10 years	0	4	4	4	4	3	3	4	4	3	4	4	4	4	3	3
152		2 - 5 years	Training	5	5	5	5	5	4	5	5	4	5	5	5	4	4	4
153		> 10 years	0	4	4	4	4	5	5	5	5	5	5	5	5	5	5	5
154		5 - 10 years	0	4	5	5	5	5	4	5	5	4	5	4	5	5	5	5
155		5 - 10 years	0	4	4	5	5	4	5	5	5	4	5	4	5	4	4	4
156		> 10 years	0	4	4	4	4	4	3	4	4	4	4	4	4	4	4	4
157		> 10 years	People must be alert about the situation about the place where	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5

				Section													
				Awareness					Zero Harm				Safety perception				
			they are going to work, dig danger														
158		> 10 years	0	5	4	5	5	5	5	5	5	4	5	4	5	5	4
159		5 - 10 years	More communication to the employees and training in regular intervals and refresher courses	4	4	3	4	3	4	5	4	4	5	5	5	4	4
160		2 - 5 years	Supervisors must ensure SOPs are understood by everyone and coaching must be done more often in all departments	5	4	5	5	4	5	5	5	4	5	5	5	5	5
161		2 - 5 years	Reassurance and adherence to the values and aspects outlined in the scope of work. Team building also plays a vital role in ensuring safety in the workplace as well as vigilance	4	4	4	4	4	5	5	4	4	5	4	5	4	4
162		2 - 5 years	More time given at start of shift to discuss safety and inspect the workplace	5	5	5	4	4	5	5	5	5	5	5	5	4	4

				Section													
				Awareness					Zero Harm				Safety perception				
163		2 - 5 years	Focus more on training people on doing their task. Safety rather than taking shortcuts	4	4	4	5	4	5	5	5	4	5	5	5	4	4
164		> 10 years	Workers must get 1-hour rest rather than working 12 hours without rest. That will improve safe working place	4	4	4	5	3	5	5	5	5	5	4	4	5	4
165		> 10 years	0	4	4	4	4	4	5	4	4	4	5	5	5	4	4
166		> 10 years	0	4	4	4	4	4	4	4	4	4	4	4	4	4	4
167		> 10 years	Communication	4	4	4	4	4	4	4	4	4	4	4	4	4	4
168		> 10 years	0	4	4	3	3	4	4	4	4	3	4	4	4	3	4
169		5 - 10 years	0	5	5	5	5	5	5	5	5	5	5	5	5	5	5
170		5 - 10 years	0	3	3	3	3	2	4	5	5	5	5	5	4	4	4
171		5 - 10 years	0	5	5	5	5	5	5	5	5	5	5	4	5	4	3
172		> 10 years	0	4	4	4	4	4	5	5	5	5	4	4	4	4	4
173		5 - 10 years	Work as a team	5	5	4	5	4	5	5	5	4	5	5	5	4	4
174		2 - 5 years	0	5	5	5	5	5	5	5	5	5	5	5	5	5	5
175		5 - 10 years	0	5	5	5	5	5	4	5	4	5	5	5	5	5	5
176		> 10 years	0	4	4	4	4	4	4	4	4	4	4	4	4	4	4
177		5 - 10 years	Enough people for the job	4	4	3	4	4	3	4	4	4	4	4	4	4	2
178		> 10 years	Communication/training	5	5	4	5	4	5	5	5	5	5	4	5	5	2

				Section													
				Awareness					Zero Harm					Safety perception			
179		2 - 5 years	0	5	5	5	5	5	5	5	5	5	5	5	5	5	5
180		> 10 years	0	5	2	3	5	5	3	5	5	5	5	3	5	4	4
181		> 10 years	0	4	4	5	4	3	5	5	4	4	5	4	4	5	4
182		> 10 years	0	5	5	5	5	5	5	5	5	5	5	5	5	5	5
183		> 10 years	0	4	5	2	4	1	4	5	5	5	5	5	5	5	5
184		2 - 5 years	0	5	3	2	2	4	4	3	3	4	4	3	4	4	4
185		> 10 years	By having a full-time safety rep, a permanent not operating machine while in other hands performing safety rep job	4	4	5	5	5	5	5	5	5	5	5	4	5	4
186		> 10 years	0	5	5	5	5	5	5	5	5	5	5	5	5	5	5
187		> 10 years	0	5	5	5	5	5	5	5	5	5	5	5	5	5	5
188		> 10 years	0	5	5	5	5	5	5	5	5	5	5	5	5	5	5
189		> 10 years	0	4	4	4	4	4	4	4	4	4	4	4	4	4	4
190		2 - 5 years	Most of incidents happen because worker did not get time to rest and working long hours we need time to rest	5	4	5	4	4	5	5	4	4	5	5	5	3	4
191		2 - 5 years	Revisit all the accidents happened in the past to prevent them from happening again.	4	4	4	5	5	5	5	5	5	5	5	5	5	5

				Section														
				Awareness					Zero Harm				Safety perception					
			Never do investigations for finding someone at fault															
192		5 - 10 years	0	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
193		> 10 years	0	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
194		5 - 10 years	0	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
195		> 10 years	0	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
196		2 - 5 years	0	5	5	5	5	5	5	5	5	4	5	5	5	5	5	5
197		> 10 years	0	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
198		> 10 years	0	5	5	5	5	4	4	5	5	5	5	5	5	5	5	4
199		> 10 years	0	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
200		5 - 10 years	0	4	4	4	4	4	4	4	4	3	4	4	3	3	3	3
201		> 10 years	0	5	4	5	4	4	5	5	5	5	5	5	5	5	5	5
202		5 - 10 years	0	4	4	4	5	4	4	5	4	4	4	4	5	4	4	4
203		5 - 10 years	Communicate	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
204		5 - 10 years	0	3	4	5	5	2	5	5	5	4	5	2	3	4	5	4
205		> 10 years	Focus on job in hand	5	5	5	5	4	5	5	5	5	5	5	5	5	5	5
206		> 10 years	0	4	4	5	5	5	5	5	5	5	5	5	4	5	5	5
207		5 - 10 years	We must always do communication with our work	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5

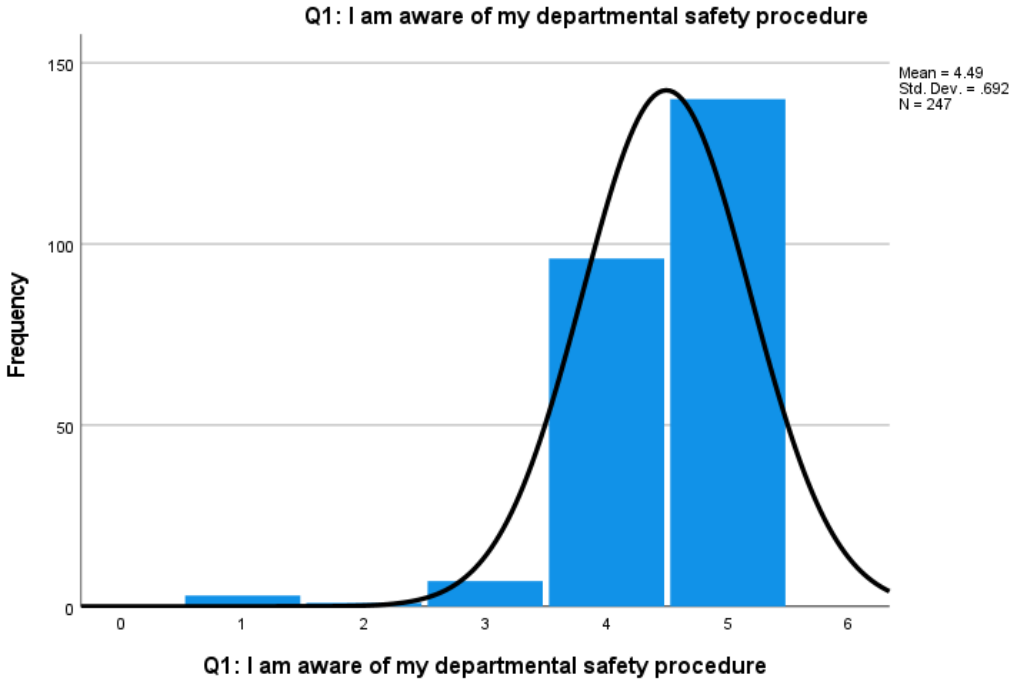
				Section													
				Awareness					Zero Harm				Safety perception				
			and retrain against our job we are doing														
208		< 1 year	Make sure that employees have the right tools for the right job. Regular inspections and employees must have enough to rest between shifts	4	5	5	5	5	5	5	5	5	5	5	5	5	5
209		2 - 5 years	Employees should comply with all the work procedures and adhere to all the safety rules and regulations	5	5	4	4	4	4	4	4	4	4	4	4	4	4
210		> 10 years	Always focus on work	5	5	5	5	5	4	5	5	5	5	5	5	5	5
211		< 1 year	All workers must get proper training and equipment to perform work productively	4	4	4	4	4	5	5	5	5	5	4	4	5	4
212		5 - 10 years	Always your mind always be focussed at work	5	5	5	5	5	4	5	5	5	5	5	5	5	5
213		5 - 10 years	Employees should comply with company procedures	5	5	5	5	5	5	5	5	5	5	5	5	5	5
214		5 - 10 years	If people can get enough rest for not too much fatigue	4	4	4	4	4	5	5	5	5	5	5	5	5	5
215		< 1 year	Perform risk assessments	4	4	4	4	4	5	5	5	4	5	5	5	4	3

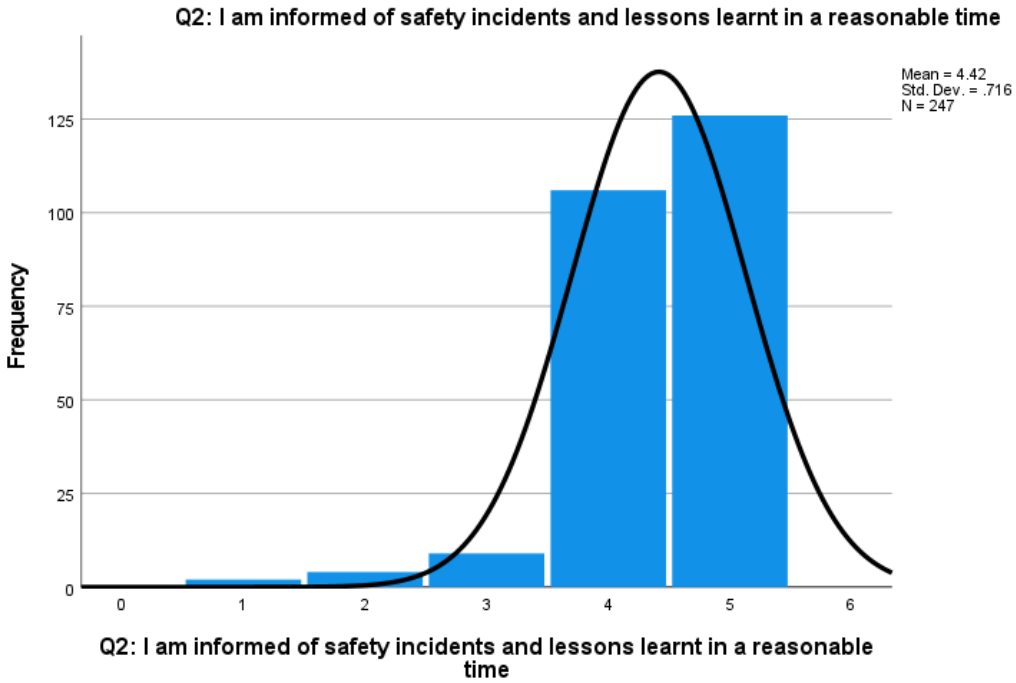
				Section													
				Awareness					Zero Harm				Safety perception				
216		5 - 10 years	Information is not given enough to the employees especially those who are going around	1	1	1	3	1	5	5	5	1	5	1	5	1	5
217		> 10 years	0	5	5	5	5	5	5	5	5	5	5	5	5	5	5
218		> 10 years	Communication	5	4	5	4	5	5	5	5	5	4	5	5	5	5
219		5 - 10 years	0	5	4	5	4	4	5	4	5	5	5	5	5	4	4
220		5 - 10 years	To motivate employees with something e.g. pen t-shirt anything to keep more effort to safety yearly or quarterly it is zero harm	4	4	4	4	4	4	4	4	4	4	4	4	4	4
221		5 - 10 years	0	5	5	5	5	5	5	5	5	5	5	5	5	5	5
222		< 1 year	Make sure employees have the right tools and equipment inspection all the time	4	4	4	4	4	4	5	4	4	5	5	5	4	4
223		< 1 year	I think for those who are new in working place must be always be reminded about their safety until they know very well about their safety underground	5	4	4	4	4	4	4	4	4	4	4	4	4	4

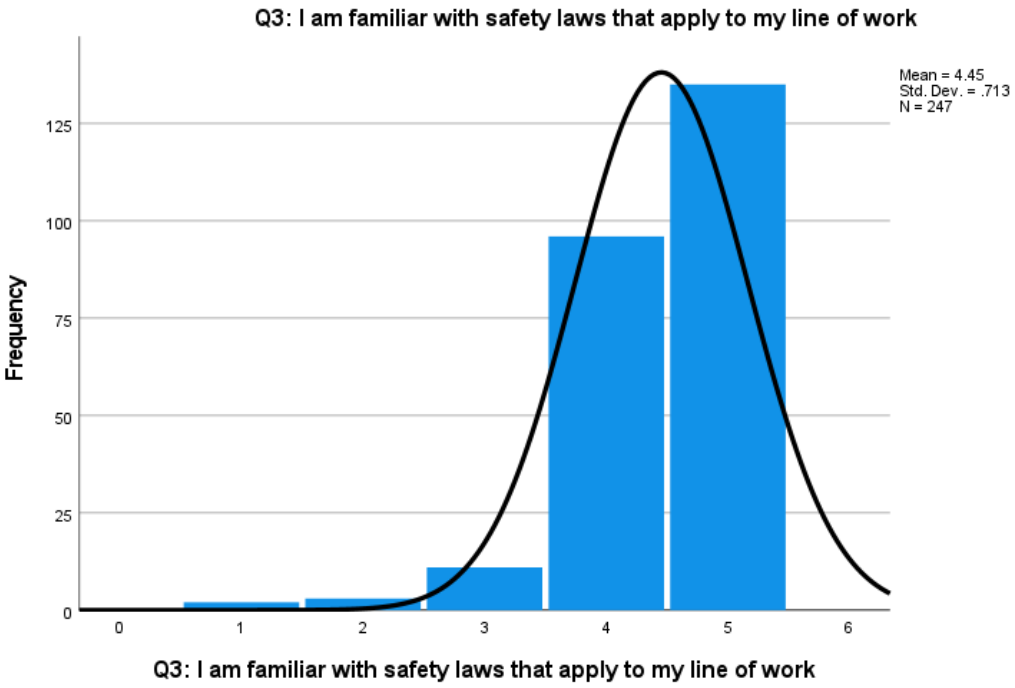
				Section													
				Awareness					Zero Harm				Safety perception				
224		< 1 year	Employees should comply more with the safety rules and precaution. Human behaviour is key to achieving zero harm	5	5	5	5	5	5	5	5	5	5	5	5	5	5
225		< 1 year	There is no workplace that need to be improve at the moment	5	4	5	5	5	4	5	4	5	5	5	4	5	4
226		< 1 year	Workers should comply with rules and regulations	5	5	5	5	5	5	5	5	5	5	5	5	5	5
227		< 1 year	Practicing and doing it on a daily basis is a good solution in a work place	4	4	4	4	5	4	5	4	4	5	5	5	4	4
228		> 10 years	0	4	4	4	4	4	5	5	5	4	5	5	5	5	4
229		5 - 10 years	0	4	2	4	4	4	4	5	5	4	5	4	4	4	4
230		2 - 5 years	0	5	5	5	5	5	1	5	5	5	5	5	5	5	5
231		2 - 5 years	Enough rest	4	5	5	4	5	4	5	4	4	5	5	4	5	5
232		5 - 10 years	0	4	4	4	4	4	4	4	4	4	4	4	4	4	4
233		2 - 5 years	Improvement in their communication skills and leaders be trustworthy, and truthful	3	4	4	4	3	4	4	4	3	4	4	4	4	4
234		> 10 years	0	5	5	5	4	5	5	5	5	5	5	5	5	5	5
235		2 - 5 years	0	5	4	5	5	4	5	5	5	5	5	5	4	5	5

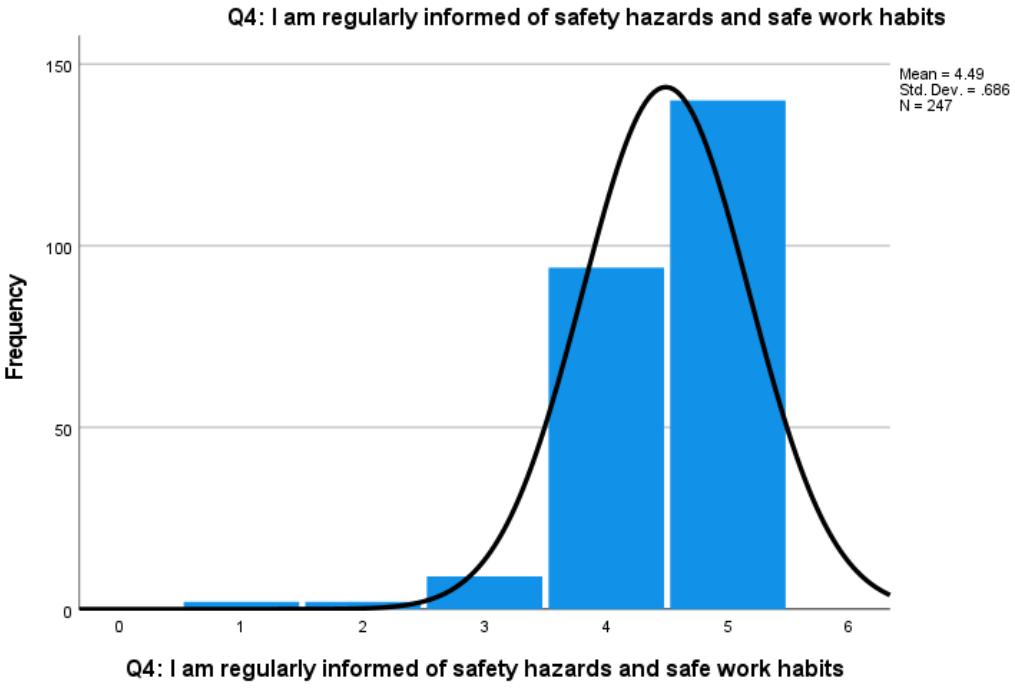
				Section													
				Awareness					Zero Harm				Safety perception				
236		> 10 years	0	5	5	5	5	5	5	5	5	5	5	5	5	5	5
237		2 - 5 years	Communicate with us	3	3	3	3	3	2	3	3	3	4	3	3	4	3
238		> 10 years	0	5	5	4	4	5	5	5	4	4	5	5	5	5	5
239		> 10 years	0	4	4	5	5	4	5	4	5	4	5	5	5	5	5
240		> 10 years	Always do housekeeping	5	5	5	5	5	5	5	5	5	5	5	5	5	5
241		> 10 years	0	4	4	4	4	4	4	5	5	5	5	5	5	5	2
242		> 10 years	0	4	2	4	5	5	4	5	5	5	5	5	5	5	5
243		> 10 years	0	5	5	5	5	5	5	5	5	5	5	5	5	5	5
244		5 - 10 years	More coaching and training to employees on the spot	4	4	4	4	4	4	4	4	4	4	4	4	4	4
245		2 - 5 years	0	5	5	5	5	5	4	4	4	4	5	5	5	5	5
246		2 - 5 years	0	4	4	4	4	5	5	5	5	4	5	5	5	5	4
247		> 10 years	0	4	4	4	4	4	4	4	4	4	4	4	4	4	4

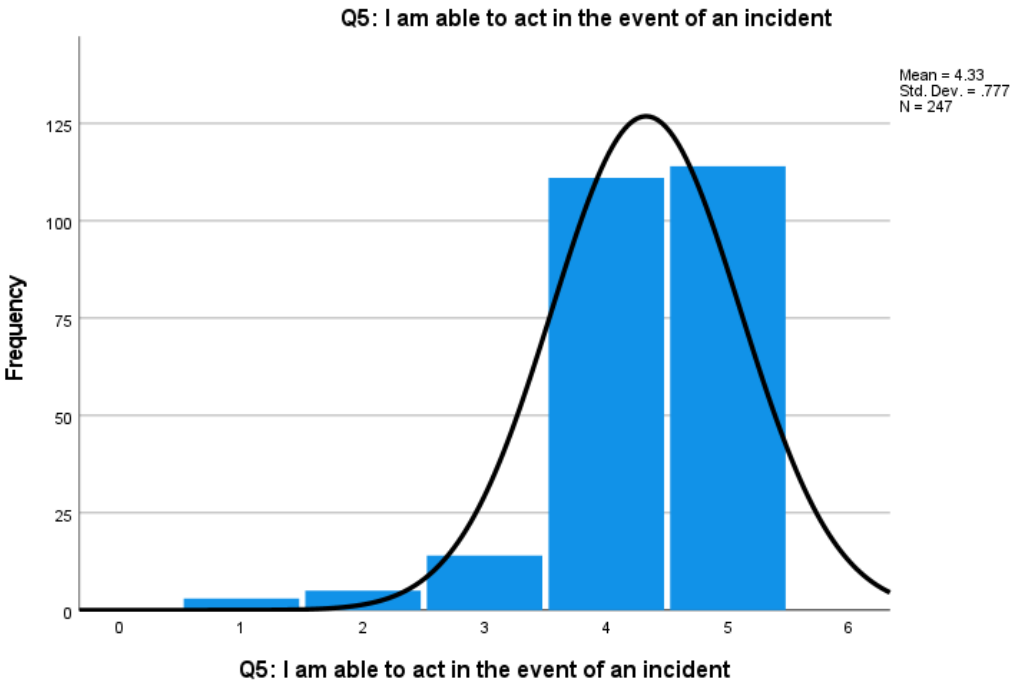
8.7. APPENDIX G: KURTOSIS AND SKEWNESS RESULTS

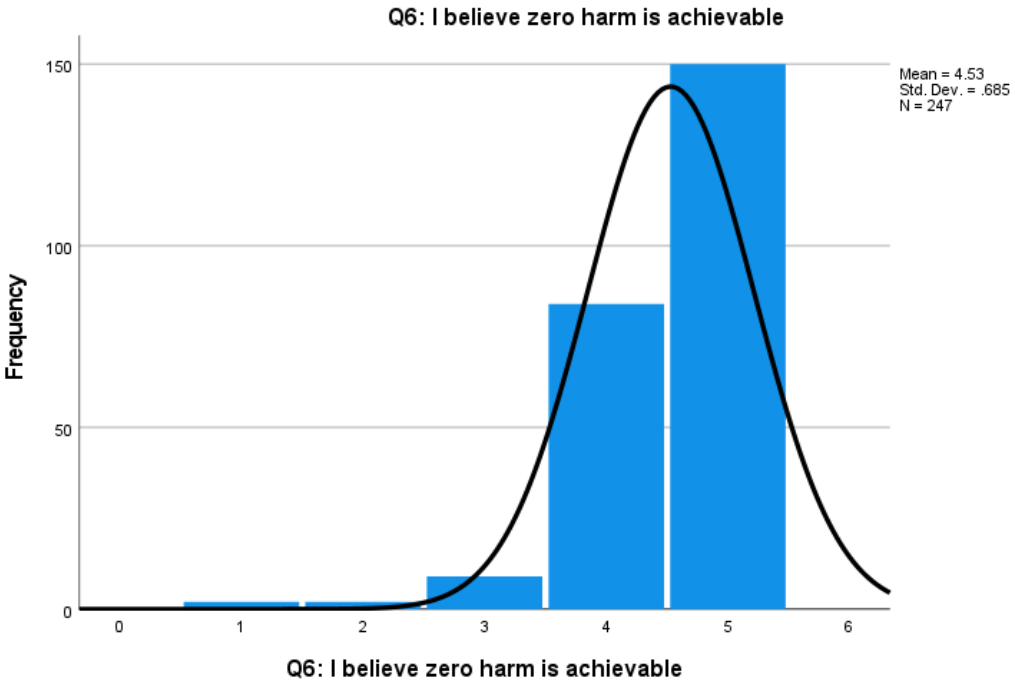


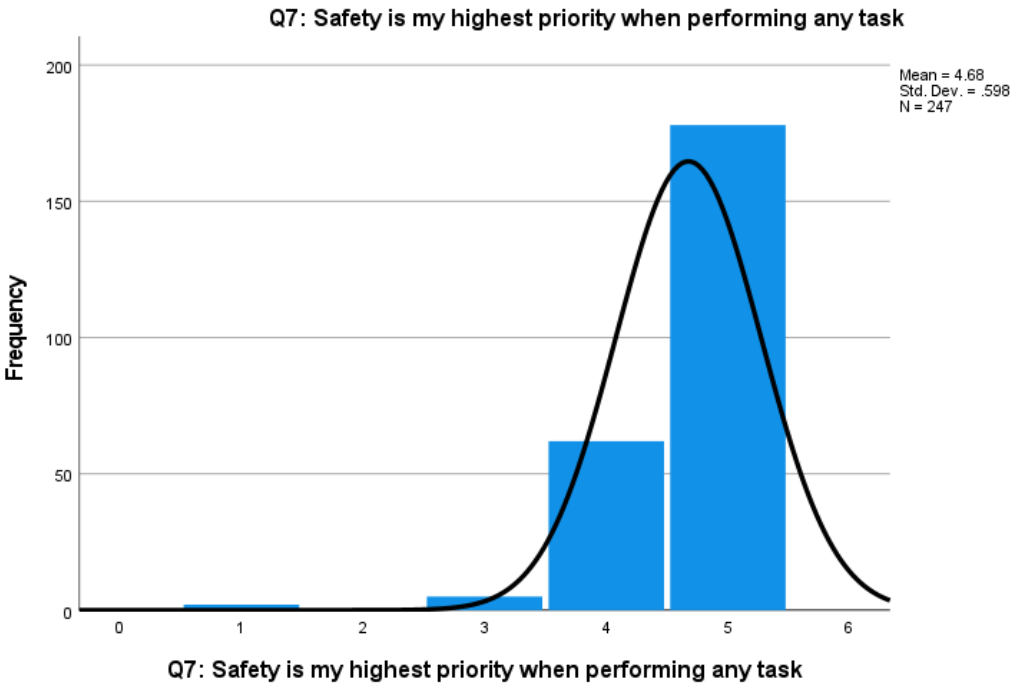


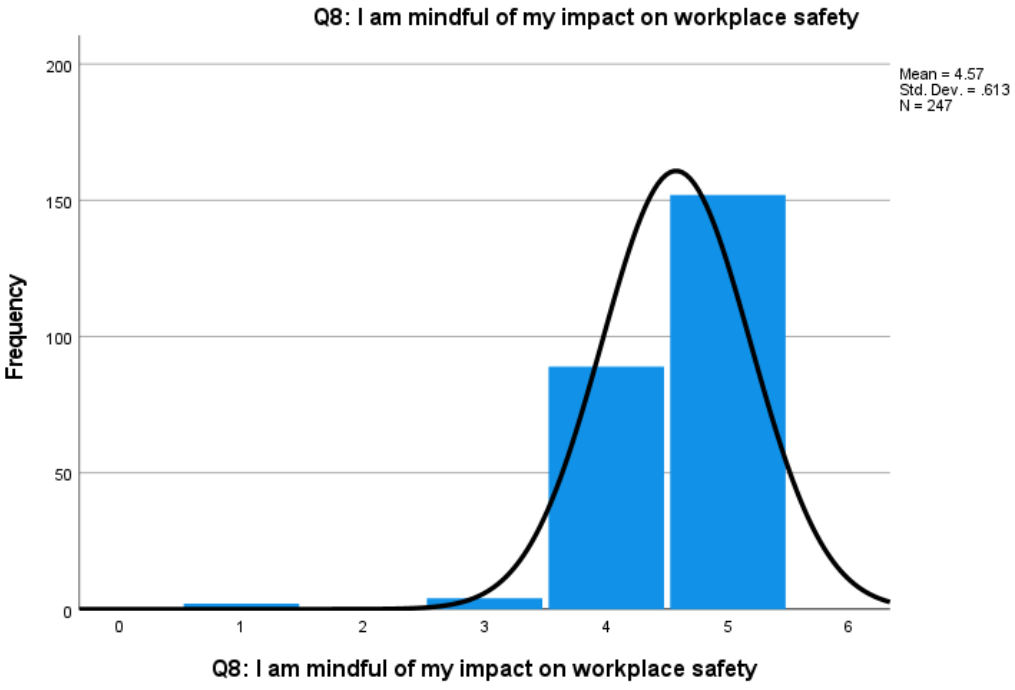

Q3: I am familiar with safety laws that apply to my line of work
Mean = 4.45
Std. Dev. = .713
N = 247
Frequency
125
100
75
50
25
0
0
1
2
3
4
5
6
Q3: I am familiar with safety laws that apply to my line of work

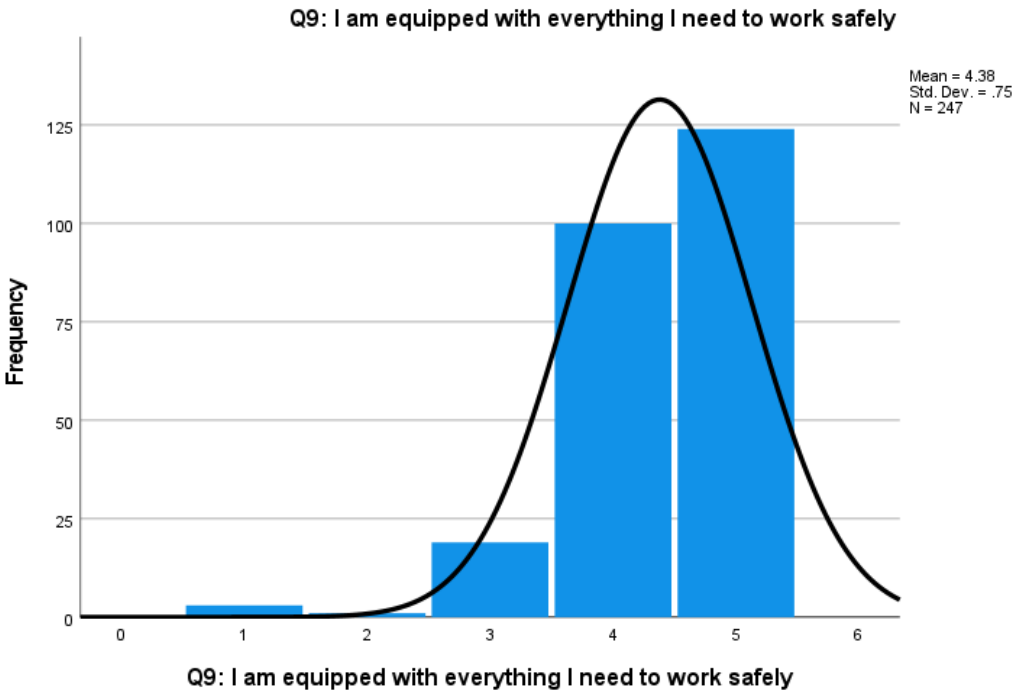

Q4: I am regularly informed of safety hazards and safe work habits
Mean = 4.49
Std. Dev. = .686
N = 247
Frequency
150
100
50
0
0
1
2
3
4
5
6
Q4: I am regularly informed of safety hazards and safe work habits

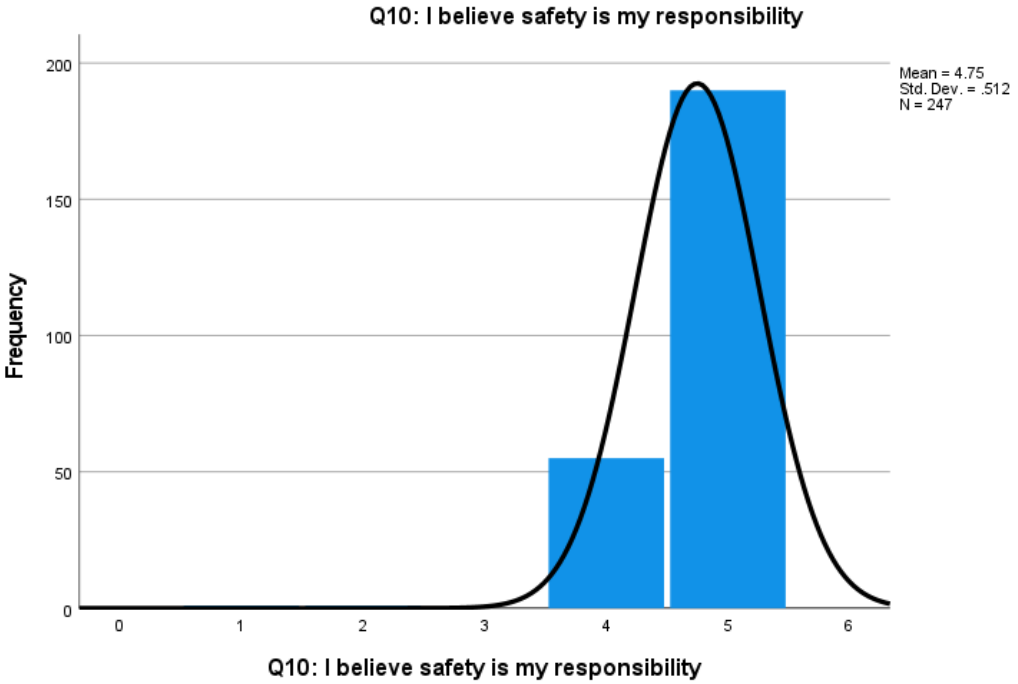

Q5: I am able to act in the event of an incident
Mean = 4.33
Std. Dev. = .777
N = 247
Frequency
125
100
75
50
25
0
0
1
2
3
4
5
6
Q5: I am able to act in the event of an incident

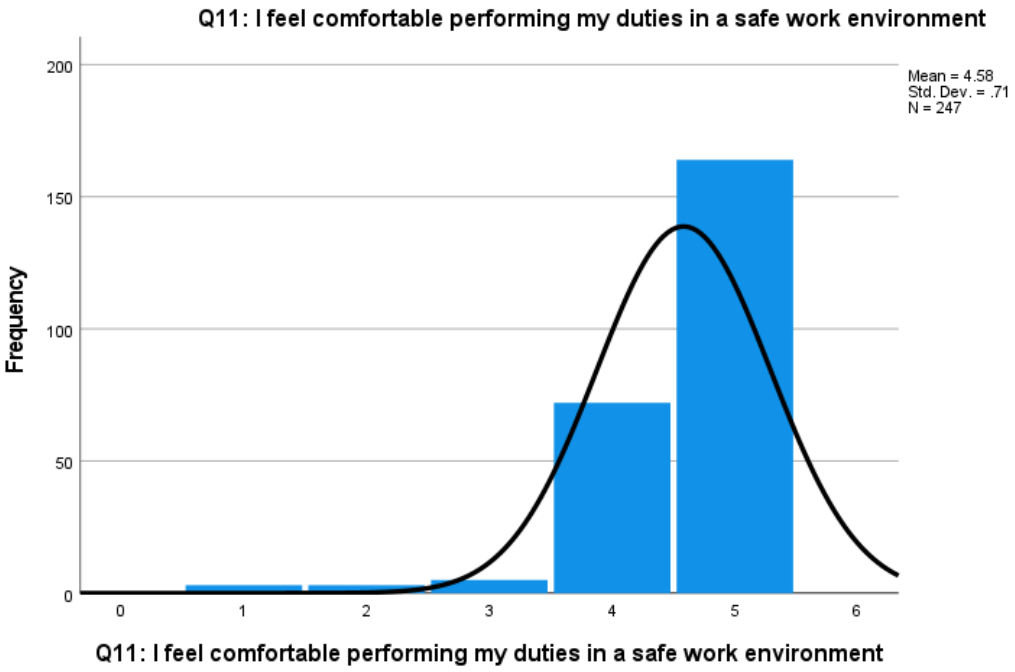

Q6: I believe zero harm is achievable
Mean = 4.53
Std. Dev. = .685
N = 247
Frequency
150
100
50
0
0
1
2
3
4
5
6
Q6: I believe zero harm is achievable

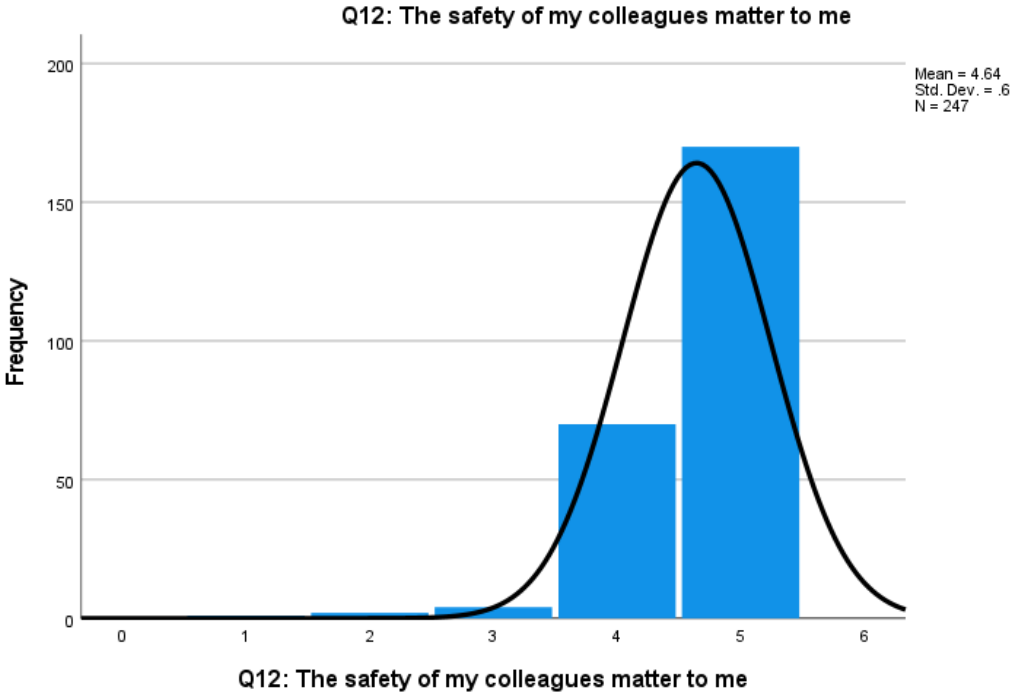

Q7: Safety is my highest priority when performing any task
Mean = 4.68
Std. Dev. = .598
N = 247
Frequency
200
150
100
50
0
0
1
2
3
4
5
6
Q7: Safety is my highest priority when performing any task


Q8: I am mindful of my impact on workplace safety
Mean = 4.57
Std. Dev. = .613
N = 247
Frequency
200
150
100
50
0
0
1
2
3
4
5
6
Q8: I am mindful of my impact on workplace safety

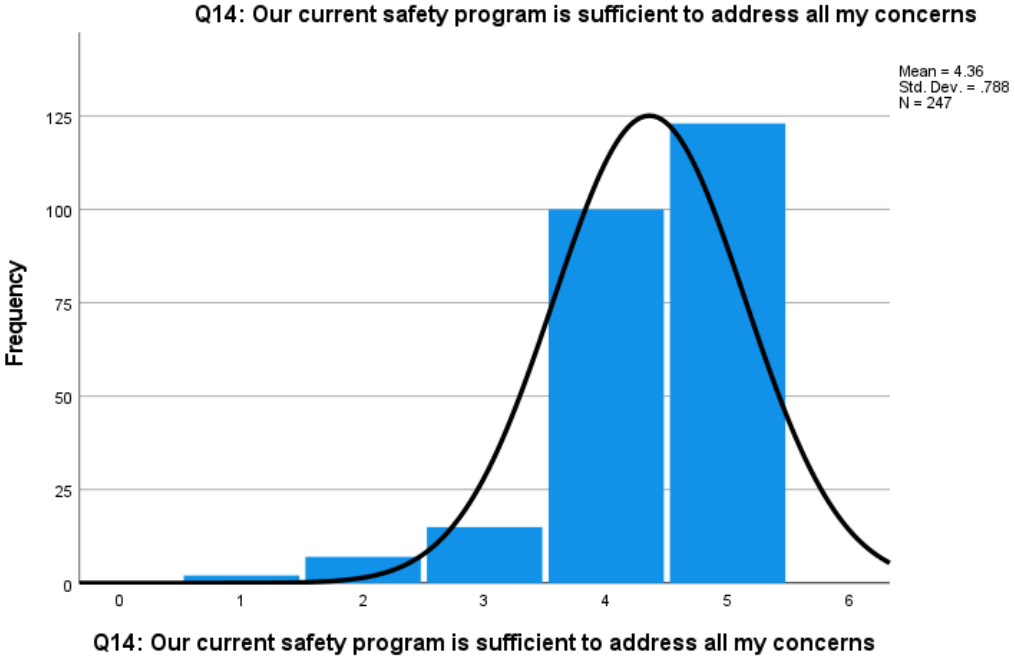

Q9: I am equipped with everything I need to work safely
Mean = 4.38
Std. Dev. = .75
N = 247
Frequency
125
100
75
50
25
0
0
1
2
3
4
5
6
Q9: I am equipped with everything I need to work safely


Q10: I believe safety is my responsibility
Mean = 4.75
Std. Dev. = .512
N = 247
Frequency
200
150
100
50
0
0
1
2
3
4
5
6
Q10: I believe safety is my responsibility


Q11: I feel comfortable performing my duties in a safe work environment
Mean = 4.58
Std. Dev. = .71
N = 247
Frequency
200
150
100
50
0
0
1
2
3
4
5
6
Q11: I feel comfortable performing my duties in a safe work environment


Q12: The safety of my colleagues matter to me
Mean = 4.64
Std. Dev. = .6
N = 247
Frequency
200
150
100
50
0
0
1
2
3
4
5
6
Q12: The safety of my colleagues matter to me


Q13: I have been trained sufficiently to perform my job safely
Mean = 4.53
Std. Dev. = .673
N = 247
Frequency
150
100
50
0
0
1
2
3
4
5
6
Q13: I have been trained sufficiently to perform my job safely


Q14: Our current safety program is sufficient to address all my concerns
Mean = 4.36
Std. Dev. = .788
N = 247
Frequency
125
100
75
50
25
0
0
1
2
3
4
5
6
Q14: Our current safety program is sufficient to address all my concerns

8.8. APPENDIX H: KRUSKAL-WALLIS TEST RESULTS

Table H- 1:Kruskal-Wallis test results

Null Hypothesis	Test	Sig.	Decision
The distribution of Q1: I am aware of my departmental safety procedure is the same across categories of QA: Colliery.	Independent-Samples Kruskal-Wallis Test	0.258	Retain the null hypothesis.
The distribution of Q2: I am informed of safety incidents and lessons learnt in a reasonable time is the same across categories of QA: Colliery.	Independent-Samples Kruskal-Wallis Test	0.159	Retain the null hypothesis.
The distribution of Q3: I am familiar with safety laws that apply to my line of work is the same across categories of QA: Colliery.	Independent-Samples Kruskal-Wallis Test	0.707	Retain the null hypothesis.
The distribution of Q4: I am regularly informed of safety hazards and safe work habits is the same across categories of QA: Colliery.	Independent-Samples Kruskal-Wallis Test	0.624	Retain the null hypothesis.
The distribution of Q5: I am able to act in the event of an incident is the same across categories of QA: Colliery.	Independent-Samples Kruskal-Wallis Test	0.854	Retain the null hypothesis.
The distribution of Q6: I believe zero harm is achievable is the same across categories of QA: Colliery.	Independent-Samples Kruskal-Wallis Test	0.147	Retain the null hypothesis.
The distribution of Q7: Safety is my highest priority when performing any task is the same across categories of QA: Colliery.	Independent-Samples Kruskal-Wallis Test	0.282	Retain the null hypothesis.
The distribution of Q8: I am mindful of my impact on workplace safety is the same across categories of QA: Colliery.	Independent-Samples Kruskal-Wallis Test	0.770	Retain the null hypothesis.

Null Hypothesis	Test	Sig.	Decision
The distribution of Q9: I am equipped with everything I need to work safely is the same across categories of QA: Colliery.	Independent-Samples Kruskal-Wallis Test	0.542	Retain the null hypothesis.
The distribution of Q10: I believe safety is my responsibility is the same across categories of QA: Colliery.	Independent-Samples Kruskal-Wallis Test	0.770	Retain the null hypothesis.
The distribution of Q11: I feel comfortable performing my duties in a safe work environment is the same across categories of QA: Colliery.	Independent-Samples Kruskal-Wallis Test	0.523	Retain the null hypothesis.
The distribution of Q12: The safety of my colleagues' matter to me is the same across categories of QA: Colliery.	Independent-Samples Kruskal-Wallis Test	0.947	Retain the null hypothesis.
The distribution of Q13: I have been trained sufficiently to perform my job safely is the same across categories of QA: Colliery.	Independent-Samples Kruskal-Wallis Test	0.426	Retain the null hypothesis.
The distribution of Q14: Our current safety program is sufficient to address all my concerns is the same across categories of QA: Colliery.	Independent-Samples Kruskal-Wallis Test	0.107	Retain the null hypothesis.

8.9. APPENDIX I: KENDALL TAU B TEST RESULTS

Table I- 1: Kendall Tau B test results

			Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Q14
Kendall Tau B	Q1	Correlation Coefficient	1	0.608	0.58	0.625	0.513	0.353	0.41	0.46	0.435	0.389	0.432	0.501	0.434	0.373
		N	247	247	247	247	247	247	247	247	247	247	247	247	247	247
	Q2	Correlation Coefficient	0.608	1	0.607	0.601	0.49	0.373	0.375	0.48	0.453	0.338	0.557	0.51	0.54	0.492
		N	247	247	247	247	247	247	247	247	247	247	247	247	247	247
	Q3	Correlation Coefficient	0.58	0.607	1	0.589	0.533	0.451	0.391	0.485	0.447	0.385	0.51	0.396	0.53	0.468
		N	247	247	247	247	247	247	247	247	247	247	247	247	247	247
	Q4	Correlation Coefficient	0.625	0.601	0.589	1	0.526	0.409	0.457	0.571	0.511	0.473	0.488	0.518	0.586	0.508
		N	247	247	247	247	247	247	247	247	247	247	247	247	247	247
	Q5	Correlation Coefficient	0.513	0.49	0.533	0.526	1	0.355	0.388	0.464	0.487	0.36	0.503	0.436	0.542	0.501
		N	247	247	247	247	247	247	247	247	247	247	247	247	247	247
	Q6	Correlation Coefficient	0.353	0.373	0.451	0.409	0.355	1	0.504	0.53	0.429	0.502	0.462	0.421	0.445	0.436

			Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Q14
		N	247	247	247	247	247	247	247	247	247	247	247	247	247	247
	Q7	**Correlation Coefficient**	0.41	0.375	0.391	0.457	0.388	0.504	1	0.583	0.434	0.641	0.537	0.529	0.48	0.404
		N	247	247	247	247	247	247	247	247	247	247	247	247	247	247
	Q8	**Correlation Coefficient**	0.46	0.48	0.485	0.571	0.464	0.53	0.583	1	0.579	0.5	0.525	0.552	0.562	0.507
		N	247	247	247	247	247	247	247	247	247	247	247	247	247	247
	Q9	**Correlation Coefficient**	0.435	0.453	0.447	0.511	0.487	0.429	0.434	0.579	1	0.44	0.444	0.369	0.578	0.519
		N	247	247	247	247	247	247	247	247	247	247	247	247	247	247
	Q10	**Correlation Coefficient**	0.389	0.338	0.385	0.473	0.36	0.502	0.641	0.5	0.44	1	0.573	0.638	0.485	0.379
		N	247	247	247	247	247	247	247	247	247	247	247	247	247	247
	Q11	**Correlation Coefficient**	0.432	0.557	0.51	0.488	0.503	0.462	0.537	0.525	0.444	0.573	1	0.596	0.662	0.54
		N	247	247	247	247	247	247	247	247	247	247	247	247	247	247
	Q12	**Correlation Coefficient**	0.501	0.51	0.396	0.518	0.436	0.421	0.529	0.552	0.369	0.638	0.596	1	0.469	0.445
		N	247	247	247	247	247	247	247	247	247	247	247	247	247	247

			Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Q14
	Q13	**Correlation Coefficient**	0.434	0.54	0.53	0.586	0.542	0.445	0.48	0.562	0.578	0.485	0.662	0.469	1	0.626
		N	247	247	247	247	247	247	247	247	247	247	247	247	247	247
	Q14	**Correlation Coefficient**	0.373	0.492	0.468	0.508	0.501	0.436	0.404	0.507	0.519	0.379	0.54	0.445	0.626	1
		N	247	247	247	247	247	247	247	247	247	247	247	247	247	247