Analytic assessment of safety training procedures in open-pit mining - case study: Letseng Diamonds mine

by

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Abstract

For decades, the mining industry has been identified as one of the top dangerous industries to be employed in. Various efforts have been made to mitigate the safety risk in mining, and even though major improvements have been realized, zero harm has not yet been achieved. As such, many in the industry have shifted from the language and the pursuit of 'zero-harm' to focus on the reduction of fatalities and lost-time injuries. While engineering controls and barricading approaches have shown significant contributions to safety performance, researchers have identified the transformation of human behavior as paramount to harm reduction. Training has been identified as a key driver for changing behavior. However, the actual relation between training and injuries is not clear. This gap is addressed in this research.

To determine the relationship between training and safety, a surface mine case study was examined. Safety and training data from Letseng Diamonds Mine, Lesotho, which employs 1,804 people to produce 126,000 carats of diamonds a year, is analyzed. A negative correlation is found between the number of injuries incurred and the number of employees who received annual refresher training. This finding confirms the need for safety training and establishes the necessity to train all workers effectively. In essence, results from this sample group and insights obtained from extensive library research on safety and training answer this main research question: Does training surface mine workers improve their safety? In this case, the answer is yes, the higher the number of workers who receive training, the fewer the number of injuries the mine experiences.

Lay Summary

Thousands of employees are injured annually during work in the mining industry. In this research, injuries refer to on-site safety incidents that require personnel involved to seek medical attention. In 2018, 6,500 injuries occurred in US mines. The numbers are higher in countries such as China and South Africa. It is therefore important to understand why injuries continue to happen despite efforts mining companies make to protect employees. One of the key efforts taken to improve safety is training. This research aims to highlight training practices in surface mining and to examine their added value in reducing the number of incidents. The research targets the mining context, not only because of the urgent need for improvement but also because academia has not yet extensively examined this group for this purpose. The research also recommends strategies to work towards achieving the minimum injury rates in the mining industry.

Preface

This is independent research completed by Retsepile Sello with guidance from university supervisors and industry partners. The work is new and not prior published, either in whole or partially.

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Acknowledgments

This research would not have been possible if Andrea; my mentor; didn’t say ‘yes’ when I told her I was interested in researching safety. I also acknowledge the help and support of my supervisors, Scott and Danielle. I appreciate Marek's support and guidance, especially during the thesis defense. I would also like to thank Allan and Jason for the editorial insight and help. Finally, special thanks go to Letseng Diamonds Health, Safety and Environment department team for working with me and teaching me the things I needed to learn to write this report.

Dedication

I dedicate this work to my therapist, Erin.

Chapter 1: Introduction

1.1 Problem Statement

An important goal for organizations is to keep all their employees safe, i.e. to ensure they return home unharmed after work. Universally, this goal has not yet been achieved [1]. Safety, which is often grouped with health to describe 'Occupational Health and Safety', is defined by the International Labor Organization and the World Health Organization as 'a state of complete physical, mental and social well-being [3].' In light of this definition, statistics show that the mining industry has been in the top five most unsafe industries to work in for decades [4]. In the United States, for example, the injury rate was as high as 1.78 per 200,000 hours worked in 2017 and companies spent US$ 28.6 million in accident response measures [5].

Surface mines experience major accidents that lead to significant injuries and the loss of human lives. The main causes of these accidents include blasting activities, i.e. fly-rock, vehicle and machinery accidents and high-wall failures [5]. Safety research for surface mines now recognizes the importance of human error and human performance in the occurrence and prevention of these accidents. In fact, 93% of surface mines accidents have been attributed to this cause [5]. On contrary, Bhatt et al. [6] studied high-wall accidents and concluded there is no particular worker behavior that makes them significantly more accident-prone, but rather just being in the pit puts workers at this high-wall failure risk. These seemingly contrasting conclusions suggest measures taken to prevent accidents should focus on improving both behavior and conditions.

1.2 Current responses to the problem

Haas et al. [7] categorized strategies mining companies employ to improve safety into three areas, ‘hazard identification and control’, ‘barricading’ and ‘cultural transformation’.

Hazard identification and control is a well-researched phenomenon in practical safety literature, yet its impact on mine safety remains limited. Hazard identification is the noting of all conditions, behaviors, and systems that have the potential to harm employees. Control refers to standard procedures taken to either eliminate the identified hazards or minimize their impact [8]. For the past decades, the industry has designed procedures to identify and control hazards but the impact has been minimal due to employees’ perceptions and attitudes towards the designed standards [9].

Limitations in implementing hazard control procedures have led to a broader investigation of safety culture and how it influences the effectiveness of other safety strategies in mining, including barricading [10]. Barricading is a control measure in which barriers are placed between employees and hazardous conditions. It is based on the belief that mining accidents result from system failures [11]. Therefore, the response becomes separating harmful conditions and people as much as possible. This is done with automation, autonomous equipment, extensive protective personal equipment, etc. As with hazard identification and control, research has shown that employees still cross the barricaded zones owing to their perception of the consequences for crossing these barricades [12]. These findings drive the need to examine safety culture and how it is built and transformed in the mining industry.

Safety culture is defined as: “Characteristics of the work environment, such as the values, rules, and common understandings that influence employees’ perceptions and attitudes about the importance that the organization places on safety [13] .” Mining companies have recognized the importance of identifying and transforming safety culture at their operations and they mainly attempt the change through training [14]. There is significant research advocating for workplace safety training as a means to change the culture [10, 15]. Many companies, therefore, spend millions of dollars annually on the development and execution of both initial and ongoing safety training programs. One report stated that the global mining industry spends US$1.1 billion annually on safety training [16]. However, it is unclear how significant the actual incremental added value of these programs is [14]. Evaluating that is the focus of this research.

Multiple other factors influence safety culture; some of which are related to training; which are outside the scope of this research. For instance, workers' demographics and general wellbeing are not only related to how easily they learn and retain training content, but they also influence their perception of change and safety regulations. Most experienced, older workers may find it difficult to change their norms and adopt new safety standards. Different demographics can also influence employees' attitudes to the training programs. Other relevant factors include organizational structures and team dynamics. Sizes and diversity in teams can influence teams’ joined attitudes to safety. The influence of leadership and how management models safety are other key factors that influence safety. These variables are examined in various other literary works, some of which are quoted in this research. However, due to limitations in data access, the scope of this research focusses precisely on the direct relationship between training and injuries.

1.3 Research Questions and Objectives

The primary research question for this study is: Does the current format of training surface mine workers improve their safety? Safety, in this context, is measured by the frequency of recorded injuries. The question aims to unpack the actual return on investment that most mining companies put into training their employees. The investment made in training includes time and monetary resources spent on developing skills and knowledge. The secondary research question is: How frequently should mining companies provide safety training modules? This question seeks to respond to an important question in training, that is, whether workers should all be trained at one time, or if small groups should be trained per period to spread the training modules across a year. There are other significant training-related questions such as how the training is delivered, who delivers it, and how the content is developed. These are outside the scope of the case study research due to limitations in data access but will be highlighted in background analysis.

The key objectives of the research are as follows:

- To highlight mining safety training practices
- To examine the value of safety training as a means of reducing mining accidents
- To recommend possible improvements to safety training

1.4 Research Justification and Contribution

1.4.1 Academic Justification

The question of training effectiveness to improve safety is a well-researched phenomenon in academia [17, 14, 18]. Industries such as healthcare and aerospace have undertaken extensive research studies in this area. However, the mining context presents specific dimensions still yet to be examined. For instance, in surface mines, not all team members get the same training, perhaps suggesting that training should incorporate aspects of leadership and influence to ignite change. Additionally, the prevailing working conditions, such as changes in weather, in surface operations invites the understanding of how training information is recalled during physical discomfort. These aspects may challenge the existing understanding of training effectiveness, therefore justifying the need for specific research focus on the mining industry.

1.4.2 Practical Justification

Training continues to be the default strategy for improving mine safety [19, 20]. The global mining industry adds at least 11,000 new workers per year [21]. This number is expected to rise as the demand for minerals increases with trends in technology. Therefore, more effective training, i.e. training which changes employee behavior and promotes safe practices, will continue to be of significant importance. Although time and financial investment in training have been rising [22], it has only been minimally studied how much is the seen return on this investment. Failure of safety to improve has major implications for the mining companies. These range from loss of lives, to major lawsuits, to loss of reputation and license to operate [23]. These consequences make this study timely and relevant to the mining companies and employees.

Chapter 2: Literature Review and Theoretical Development

Occupational safety is an extensively researched subject in academia. Most scholars focus on the causes of safety incidents. Other works strategize to minimize such incidents in different industries. For the mining industry context, training has been recognized as a primary intervention strategy for safety [14]. Accordingly, three main subjects are found important in understanding the role played by training in safety. These are organizational performance theories – which explain the incidents trends; organizational change theories – which establish effective transformational measures to improve the safety patterns; and organizational learning theories – which measure the value of training in safety [24].

2.1 Organizational Performance

Organizational performance, in this case, a mining company's safety performance, is often the starting point to understanding improvement [25]. Performance is defined as a measure of achievement for set goals [26]. Most surface mining companies annually set safety goals to improve safety. A common touted goal is known as 'zero harm', and is often set but has never been achieved. Despite this fact, companies continue to review their present performance and set annual goals based on this unachievable premise [14]. Other practical performance goals in the industry now include the least number of lost time injuries and most number of days worked without safety incidents. When setting these goals, the companies consider their risk matrices, their input resources and the measures taken towards improving safety and their safety culture [27].

Among the three factors which mining companies attribute to safety performance, high-performance work systems (HPWS) principle identifies input resources and measures taken to improve safety as critical [28]. This principle identifies four direct drivers for any workplace organizational performance. These are technology; work reorganization; employee selection and skill; and performance incentives. The adoption of technology has been on the rise in the mining industry [29]. This is the case in terms of system technologies such as autonomous trucks and equipment. It is also significantly rising in terms of safety training technologies such as virtual reality training tools. Work reorganization can be assumed constant as most mining companies often maintain consistent structures for a significant amount of time. The number of highly skilled labor, diverse workers and university graduates in the industry have been rising in recent years [30]. Additionally, performance incentives have been increasing to encourage safe behaviors [31]. These trends deduce that safety performance in the mining industry should have improved over recent years. This formulates our first hypothesis that the global mining industry has seen a decline in the number of injuries from investing in technology, hiring skilled labor and adopting performance incentives. Studying the state of safety at a surface mine will reflect similar patterns. (Figure 1)

H1: Investing in HPWS is negatively associated with the number of injuries.

Figure 1: Hypothesis 1 – Trends causing the decline in injuries

2.2 Organizational Change

The most commonly known model of change is Lewin's Three-Step Model which states that for any lasting change to occur, the organization must undergo three stages; 'unfreeze', 'change' and 'refreeze'[32]. Safety culture transformation happens through a similar process. In mining, training is intended to be the ‘unfreezing’ agent of change [14]. Other strategies such as performance incentives and consequence management strategies are used to enable change and to ‘refreeze’ the system. Therefore, our analysis will focus on the ‘unfreezing’ stage of Lewin's Model. Lewin’s model is often used in conjunction with John’s Kotter’s 8 Step Model which gives specific action items for each stage of Lewin’s model [33]. Kotter suggests that for a safety training to ‘unfreeze’ safety culture, it should establish a sense of urgency, create the guiding coalition, develop a vision and strategy, and communicate the change vision [32].

Weihagen et al. [24] studied several mining companies and training trends and developed an overall model used by the industry to determine workers’ training needs. This model established that in mine safety training, individual workers’ differences in knowledge are measured, specific content is developed for different teams and feedback from previous training modules is incorporated. This approach guides a coalition by training workers in their teams. It develops clear visions and strategies by focusing on individuals’ training needs. It also communicates the vision when feedback is communicated and incorporated in future sessions. Therefore, although it is unclear whether a sense of urgency is established, fulfilling three of the four requirements of Kotter's model suggests that training will act as a change agent and will improve safety. This model, therefore informs our second hypothesis:

Hypothesis 2: Providing annual safety training to all surface mine workers is associated with an increase in the overall safety performance of the mine. (Figure 2)

Does safety training…

Establish a sense of urgency to change safety-related behavior?	Unclear
Create a guiding coalition to inspire all employees to work safely?	Yes
Develop a vision and strategy for excellent safety performance?	Yes
Communicate the change vision in a way that is clear and understandable to all employees?	Yes

→ Increase in safety performance

Figure 2: Hypothesis 2 - Kotter's Model for safety performance improvement

2.3 Organizational Learning

Under Organizational Learning, many scholars focus either on the 'thinking' part of the learning process, i.e. 'the cognitive school' or the 'doing' aspect of it, i.e. 'the behavioral school'. The difference between these is that cognitive school researchers believe that people learn by forming mental models and patterns while the behavioral school believes learning takes place through experiences [34]. Mining employees primarily learn from practice since they tend to do similar tasks daily (24). Their 'behavioral' engagement with the training material is, therefore, more important and informs which theories are relevant in assessing the training programs. It also informs how long workers can retain the material.

The strategic content development and delivery processes that are taken in the mining industry, especially in recent years, ensure that actual material learning does take place when workers are taught [9]. It is however still unclear how long workers retain the knowledge gained. The knowledge depreciation theory established by Argote [35] shows that in any sort of organizational learning, knowledge depreciates with time. The major cause of this is the changes in relevant information that makes old knowledge obsolete. The depreciation rate is, therefore, faster in industries that are growing and changing rapidly. The 21st-century mining industry is changing rapidly in terms of standards, regulations, and technologies and therefore, so will safety knowledge after it is taught.

There are two ways that mining companies can strategically train their workers to capitalize on both the learning models and knowledge depreciation capacity. They can either retrain all their workers as often as possible, so that everyone is always up to date with standards and regulations, or they can spread the training over a year, training a portion of the workers each time. The latter is often implemented by most companies in the industry [24]. Training workers in small groups over a long period makes sense both practically and theoretically. With few people in training, operations can go on as usual and this will not significantly affect production. Theoretically, people who are just retrained are likely to influence their fellow workers to adhere to standards and therefore influence higher safety performance. Both these reasons inform the third hypothesis for this study.

Hypothesis 3: Overall safety performance is higher when the number of employees recently exposed to safety training is higher.

The basis of this third hypothesis is that the more employees a mine trains per given time, the more they can influence their fellow workers with safer operating procedures. However, with knowledge depreciation theory, going for long periods without training would jeopardize the mine's overall working knowledge and deteriorate safety performance [36]. A suitable compromise is, therefore, to train an equal number of workers (highest possible) per period and have multiple periods a year.

The three developed hypotheses form the basis for this study and they can be presented with a framework in Figure 3. Some of the factors that theoretically influence safety performance could are not analyzed in the case study due to data limitations. These are italicized in Figure 3.

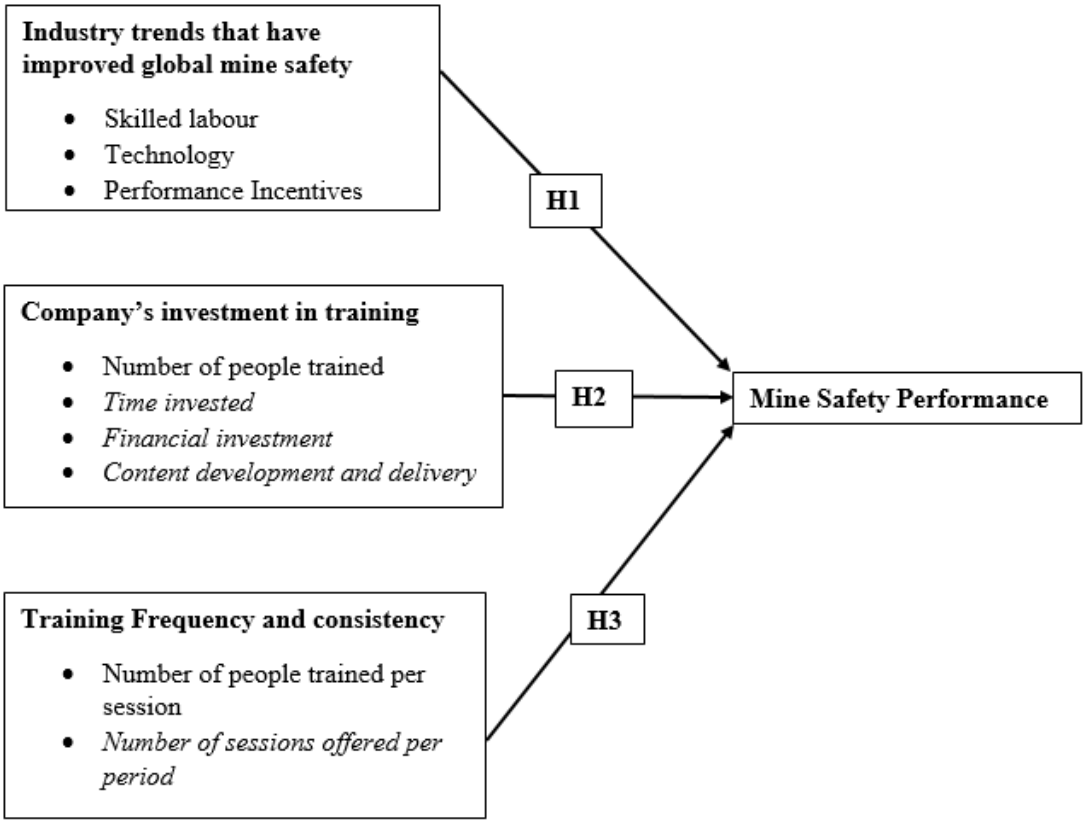

Figure 3: Safety performance model

Chapter 3: Research Methodology

3.1 Case Study Background

3.1.1 Structural Profile

Letseng Diamond Mine is located in the northern part of Lesotho. Gem Diamonds Limited owns 70% of the shares on the mine and the government of Lesotho owns 30%. The current operation was opened in 2006 and has a planned mine life of over 20 years. This is a 365 days, 24 hours operation with production at around 126,000 carats per year. The mine, however, bears a very low grade of under two carats per 100 tonnes and processes 6, 239, 000 tonnes of ore to reach target carats [37]. This high activity, together with the current organizational structure, make this mine an interesting case study for a mine safety research.

Letseng Diamonds directly controls some of the facilities, infrastructure and activities onsite. However, contractors run the majority of operational activities. In particular, Letseng takes direct responsibility for all safety and environmental aspects of the whole mine. It also controls water systems, blasting activities, and final recovery operations. Its major contractors handle drilling, loading and hauling; mineral processing up to final recovery; tailings management; security (except that of recovery, which is directly managed by Letseng); health and medical services; catering and housekeeping; and explosives handling. A different contractor handles each of these major tasks. Nonetheless, Letseng has a health and safety officer based at each of the contractor's areas to monitor safety enforce the company's safety rules [37]. The mine is not unionized, however, the company is certified by DQS Management System Solutions to use the ISO 45001 International Organization for Standardization Safety guideline to formulate its safety regulations [37].

3.1.2 Safety Strategies

Letseng employs various strategies to both prevent injuries and mitigate their consequences when they occur. Corporate and management strategy includes safety policy process and explicit top management involvement in safety. Preventative strategies include Hazard Identification through baseline and continuous risk assessments, Behavior-Based Care (BBC) and Planned Task Observations (PTOs). Monitoring strategies are audits and inspections. Responsive strategies include incidents and consequence management. However, the strategy which ties all these other ones together is training and that is why this research focuses on this subject.

Policy and Leadership Commitment

Top management develops the HSE policy. It consults all levels and all occupations through meetings to establish updates on the policy on an annual basis. Other considerations in these updates include new hazards and risks; corporate goals and objectives; HSE performance; and legal requirements. Once developed, the HSE team distributes the policy to all employees and contractors and communicates it in training. The team also makes it available to all stakeholders so that everyone understands their roles and responsibilities.

At Letseng, management takes full responsibility for safety. An HSE manager leads the safety team. Lower-level managers and department leaders support the manager to ensure that employees know and respect the set safety rules. Appendix D shows this department’s organogram. There is also a clear description of every leader's responsibilities and required actions regarding enforcing safety, starting from the company’s CEO.

HIRA and BBC

Hazard Identification and Risk Assessment (HIRA) is one of the key strategies that Letseng uses to prevent injuries. Each department head leads the process of identifying all risks and hazards associated with tasks and conditions that their employees work on. They then draw a comprehensive baseline risk-assessment matrix annually, which identifies the risks and their consequences. This matrix also explains the mitigation strategy for each risk. Additionally, before performing each task, employees are required to perform and document a mini-risk assessment.

Behavior-Based Care (BBC) works similarly to HIRA but focusses on employees' behavioral responses to safety regulations. Letseng adopted this program in 2010. It classifies employees' behavior into Care Behavior and At-risk behavior and explains how employees choose either because of how they perceive the consequences of their behavior. All departments at Letseng made a team pact under this program to define their departmental commitments to safety and they recite them in all their morning toolbox talks (safety meetings). In addition, a rigorous reporting system in BBC enables employees to report all behaviors, either positive or negative, that affect safety and to coach and correct one another to encourage accountability.

Inspections and Audits

For safety monitoring, Letseng uses inspections. They work to identify and report existing and potential hazards. Department heads and supervisors define aspects that need inspection and conditions that require regular testing in their respective areas. They then draw out a checklist that needs to be approved by the safety manager. Depending on the associated hazards, areas are required to be inspected anywhere from daily to every two years and inspectors keep a registry. When inspectors identify a hazard/potential hazard, they immediately inform the supervisor responsible for the area and the HSE practitioner in that department to take proper corrective action.

Another form of monitoring used is safety audits. Auditing committees carry out both internal and external safety audits with reference to the ISO 45001 [Occupational Health and Safety] standards. The mine has DQS Management System Solutions certification to use this ISO 45001 International Organization for Standardization audit guideline to carry out internal audits. DQS carries out external audits using the guidelines of the same standards. Both external and internal audits cover the entire mine with all of its activities. Auditors write reports at the end of the audits and communicate them to the respective departments so that they can take corrective actions.

Incidents Management

Incidents Management covers identification, reporting, recording, investigation, analysis, response and evaluation for safety incidents. All employees are responsible for identifying all non-conformities, near misses and safety incidents. They then report them to supervisors who then record them in the appropriate system and assign responsible people to investigate and respond accordingly. The investigation can be done using the Root Cause Analysis Tool model, the 5 WHY investigation framework or formal eyewitnesses and meetings investigations depending on the severity of the incident. The safety team is responsible for analyzing all the recorded incidents to determine patterns and develop material such as training modules for mitigation.

Rewards and Consequences system

There is a reward system active at Letseng that recognizes employees for exceptional safety performance. For instance, within this system, there is an employee of the month recognition for an individual who either has a high track record in HSE actions and behaviors or has performed an extraordinary safety intervention. Groups and teams that have high safety records are also recognized. Similar to the rewards system, a consequence management system addresses violations of safety regulations. Some of the activities that command employee discipline include going to work under the influence of drugs and/or alcohol; not obeying road safety rules; illegal activities onsite and operating equipment/entering spaces without permission. The mine has a disciplinary committee that analyzes each case of violation and decides on the appropriate disciplinary action.

3.1.3 Safety Training Overview

Letseng Diamonds defines competence requirements or training needs that can affect employee safety performance. It then designs modules for those competencies and delivers them to employees according to their tasks. Letseng takes responsibility for the competency of all of its contractors' personnel as well. The company also monitors competence, assesses performance and evaluates training effectiveness to ensure continual improvement in safety. The modules have not changed significantly in the four years during which this research was done.

To develop specific training modules, the company considers HIRA outcomes, incident reports, legal requirements, corporate requirements, operational objectives, and employees' input. Training needs are defined per individual occupation. Heads of departments in each of the occupations define the task-specific training needs and present them to the safety team, which then develops the modules. Some modules are delivered internally, while others require external service providers. One of the training modules that is offered internally is Induction.

There are three categories of employee induction at Letseng. The first one is the 'LD General Induction training.' It includes gate induction and mine-wide components. It is given to all new hires. It covers employees' legislative duties and rights; Letseng safety requirements and policies; risks and hazards; emergency response procedures and personal security arrangements. The training is 1 hour long and is delivered to groups or individuals. The second category is 'Site-Specific Induction'. This is provided in each functional area by the site-specific safety officer. It covers specific risks and hazards associated with the area and safety measures and requirements. Finally, there is 'Refresher Induction', which is given annually to all employees.

Apart from Induction, there are other types of safety training modules that are offered internally. These include Behavior-Based Care training, road safety, chemical safety, etc. All these modules have refreshers that occur either every year, every second year or every third year depending on the necessity. For instance, both first aid training certificates and safe driving onsite authorization and licenses are valid for two years. For training that requires external service providers, Letseng either brings in the specialists or sends out the relevant employees to receive the training externally. This happens when the mine does not have the internal expertise to deliver the training. An example of such a case is with the Emergency Responders training and firefighting training.

The effectiveness of safety training to minimize the occurrence of injuries is measured systematically. A skills assessment form is filled out before the training. During the training, there are open discussions that enable the flow of feedback to the trainer. Immediately after training, participants fill out a training evaluation forms and a month later, the heads of departments/supervisors have to carry out the Planned Task Observations to evaluate if employee safety performance improved after the training. In some cases, there are even external/internal evaluators who are invited to observe and give feedback on the training.

3.2 Sample Description

Letseng Diamonds mine employees, in the years 2015 – 2018, are the sample group for this study. There have been 1,804 employees on average for the past four years. The number of employees has been increasing steadily (Figure 4). Specifically, it rose from 1, 536 in 2015 to 2,093 in 2018. This was a 27% increase and is highly significant when evaluating training delivery and change in the number of resources invested in training. Figure 5 shows that there are no major differences in the number of employees onsite on a monthly basis. This suggests that the mine does not invest in seasonal employment but rather in long-term contracts. On a similar note, the number of man-hours worked per year has also increased by 27% in the four years and shows no major fluctuations within different months. The company is therefore on a steady growth path.

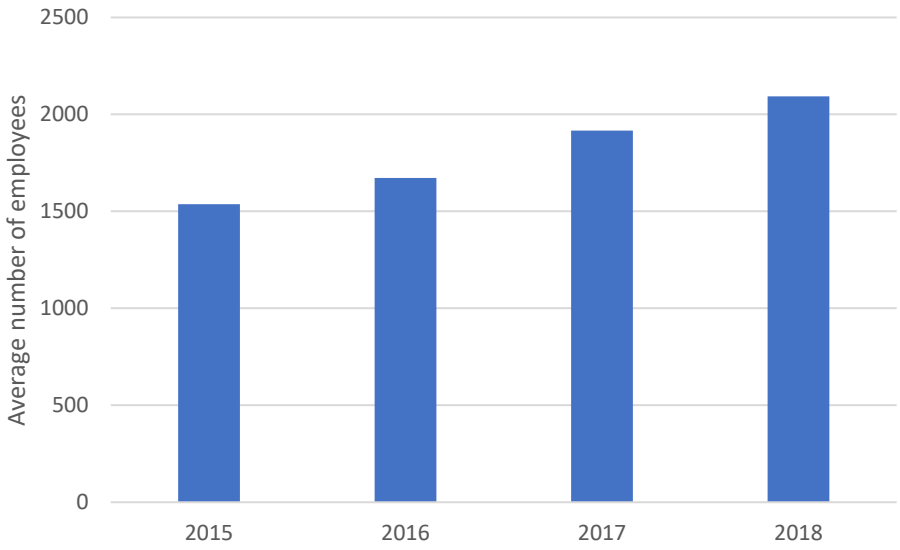

Figure 4: Average number of employees in each of the four years

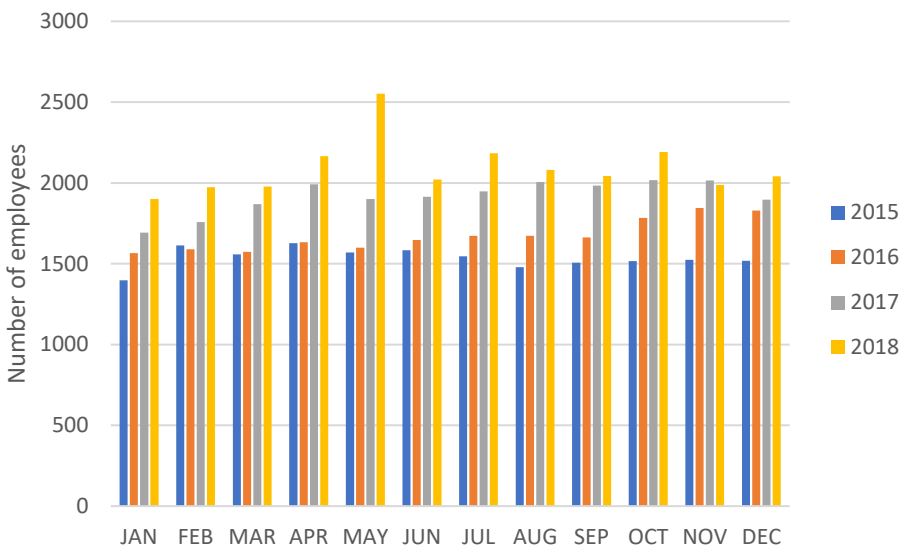

Figure 5: Number of employees on-site in different months

Letseng mine currently employs over 97% Basotho nationals as required by its operating license. Only in cases of special skills are foreign nationals employed. This means a large majority of people speak Sesotho, yet the language of instruction and training is English. Table 1 shows an overview of the staff demographics in 2017 and 2018. About 20% of the total workforce is female. Additionally, 77% of employees are between the ages of 31 and 50.

Table 1: Staff demographics [37]

Group staff demographics (%) Employee level	% male	% female	% local citizens	% age <30	% age 31 to 50	% age >50
2018						
Governance Committee Board*	100	0	25	0	55	0
Senior management	89	11	83	6	50	44
Middle management	82	18	87	7	77	16
Total workforce	80	20	96	12	76	14
2017						
Governance Committee Board*	100	0	26	0	41	59
Senior management	92	8	69	0	46	54
Middle management	78	22	84	1	81	18
Total workforce	81	19	97	14	74	12

** Includes subsidiaries.*

3.3 Research Procedure

This study uses two processes to analyze and evaluate the relationship between safety training and safety incidents at Letseng. Firstly, it evaluates the correlations between reported incidents and injuries and between reported incidents and the number of people trained. Secondly, the study examines the quality of training as it responds to the risk registry and recommends improvement. Data used in this research were collected over four years, 2015 to 2018, by the Letseng Safety department.

3.3.1 Assumptions

There are two major assumptions made in this research. The study assumes that data collection was consistent for the past four years. It is reasonable to make this assumption because data recording and processing procedures appear to be constant. The assumption allows for data usage without an in-depth consideration of biases and inconsistencies that occurred when collecting it.

The second major assumption is that there were no major changes in training in the past four years. The study makes this assumption because available data and reports do not show changes in training content, or the overall curriculum or in assessment strategies. The significant changes are in the number of people trained and the hours spent, both of which form the major part of the analysis.

3.4 Measures

The research measures both the training and injury variables. In terms of training, the number of hours spent in training and the number of people trained is the independent variables. On the safety side, the numbers of reported incidents, minor injuries, restricted work injuries, lost time injuries, and fatalities are the independent variables. Below are the definitions of the variables:

- Hours spent in training: These are the total hours spent in new inductions, refresher inductions, and all other safety-training modules.
- People trained: This is a sum of all employees, including contractors, who received any form of safety training provided internally, excluding inductions.
- Reported incidents*:* These cover all reports of non-confirmative behaviors, unsafe conditions, and near misses.
- Minor injuries: Number of reported injuries that required first aid or medical attention, but the affected employee returned to work on the same day after being treated.
- Restricted work injuries: Total number of injuries that required management to alter employees' job tasks to respond to the injury.
- Lost time injuries: Number of injuries that required the affected employees to take over a day off work to recover.

Chapter 4: Results

4.1 Quantitative Results

4.1.1 Safety Statistical Overview

Letseng measures safety in terms of reported incidents and incurred injuries. Reported incidents include all non-conformances, unsafe conditions, maintenance issues, equipment malfunctions and near misses, everything that can cause injury if left uncorrected. Employees report incidents. In the past four years, 2015 – 2018, there have been over 1,000 incidents reported each year. The peak number of incidents was in 2017 at 2,030 incidents reported. 2018 had the lowest number reported at 1,256 (Figure 6). The monthly analysis of incidents reporting shows that on average, the number of incidents reported increases as the year progresses (Figure 7). January and February have the lowest average reporting at only 74 and 72 respectively. The highest reported number of incidents is in September at 188.

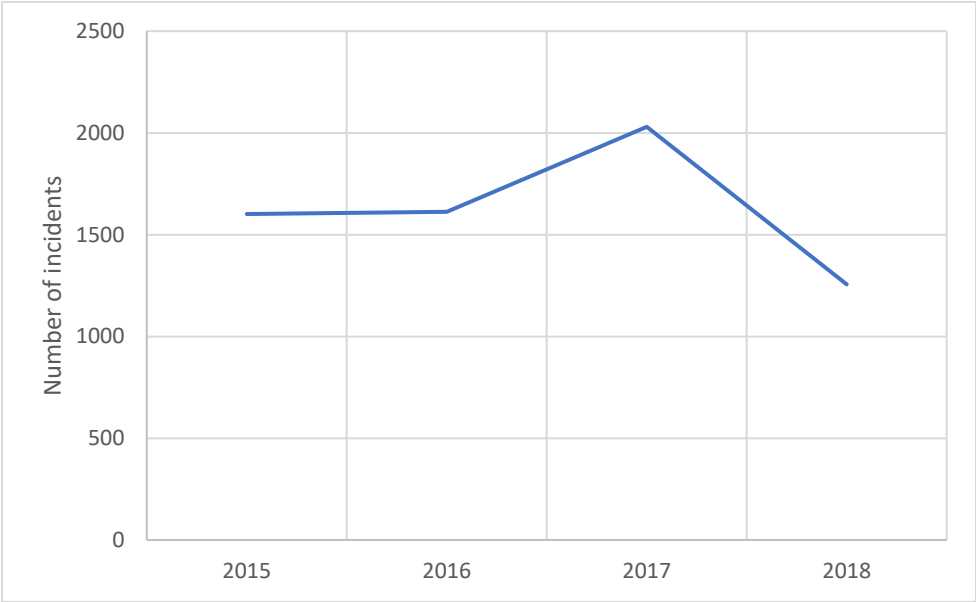

Figure 6: Annual number of incidents reported

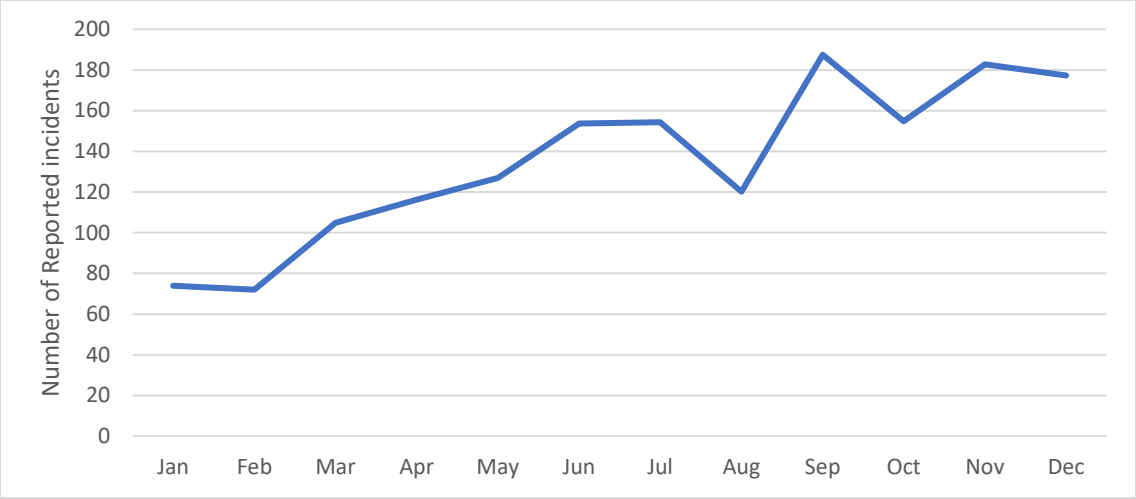

Figure 7: Monthly 4yr average number of incidents reported

The second measure of safety is the number of employee injuries. The total number of injuries is increasing and peaks at 55 injuries in 2017. Minor injuries show a similar trend with a count of 47 also in 2017. Restricted work injuries are also at their highest at seven in 2017. In contrast, lost time injuries have their peak at four in 2018 (Figure 8). In terms of monthly analysis, there seems to be no distinct pattern in injuries as they all show different fluctuations (Figure 9). However, the number of injuries peaks in September for most of the analyzed years. Every year, there is a significantly higher number of minor injuries than any other type of injury.

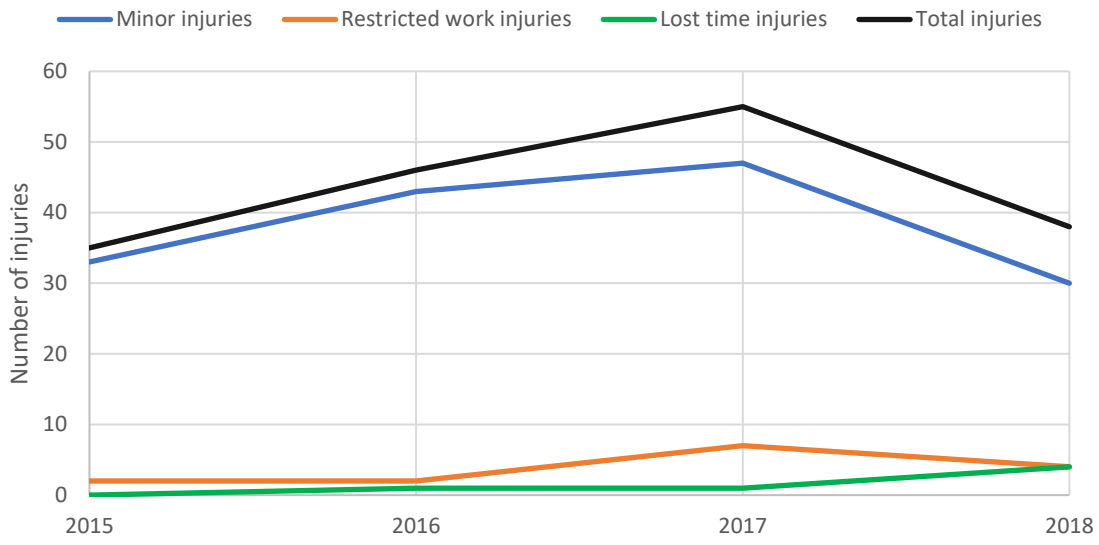

Figure 8: Annual injuries

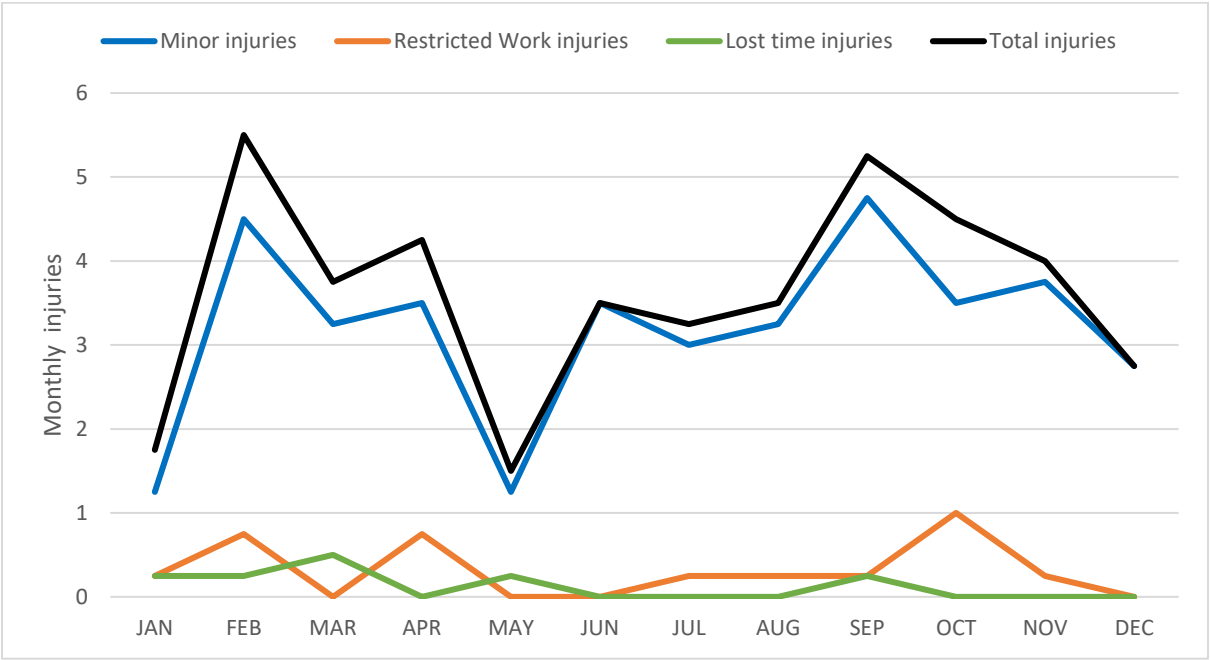

Figure 9: Monthly number of injuries (4yrs average)

4.1.2 Training Statistical Overview

This research categorizes training into three main groups: new inductions, re-inductions, and safety training, which encompasses all safety-related modules offered internally. The new inductions correspond to the number of new hires. They show steady growth from 136 in 2015 to 304 in 2018, a 55% increase that may be indicative of potential company growth (Figure 10). There are no significant variations in the monthly number of new inductions given, except from a sudden rise to 137 new inductions in April 2017. This was 6 times as high as the average monthly number over the 4 years, which is 20. See Figure 11. The research did not find any corresponding significant event to explain the rise in April, so it can be attributed to either an error in data recording or major seasonal hiring.

Each employee has to undertake a refresher safety induction annually. However, despite the apparent increase in the total number of employees, there has been no corresponding increase in the number of re-inductions given (Figure 10). They, however, decreased from 1, 226 in 2015 to 1, 146 in 2018; a 7% decrease. This implies that each year, some employees go without annual refresher training. On average, 477 employees spent a year untrained. There is also a significant 33% decrease in 2017. Analysis of monthly inductions shows no apparent patterns. See Figure 11. They fluctuate across the months with two high spikes of 555 in February 2016 and 606 in September 2018.

Several safety-training modules are offered internally each year, (Appendix A1 shows list). Examples of these include first aid, fire safety, and chemical safety. They are given to specific employees according to their specific tasks. The number of people who received these has steadily increased (Figure 10). Specifically, it increased by 34% between 2015 and 2018. Similar to new and refresher inductions, there is no particular pattern in the monthly fluctuations for this variable (Figure 11). Overall, the total number of people who receive some kind of safety training or induction has increased in the past four years.

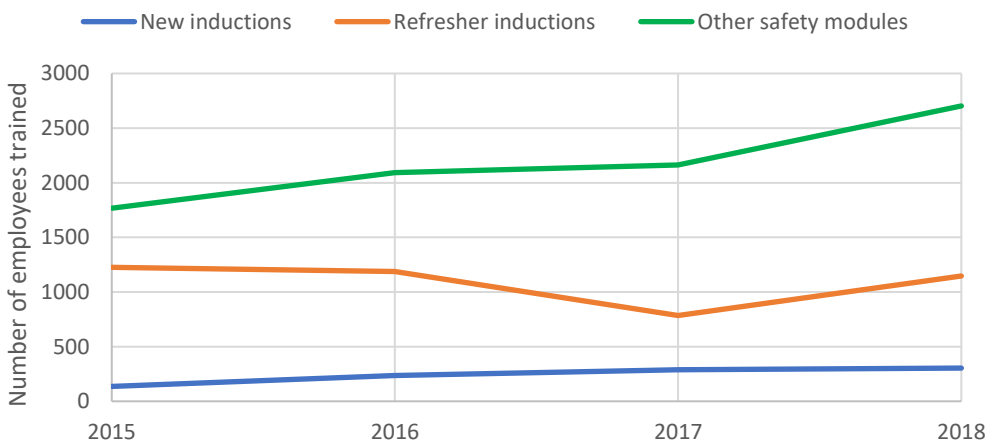

Figure 10: Annual safety training

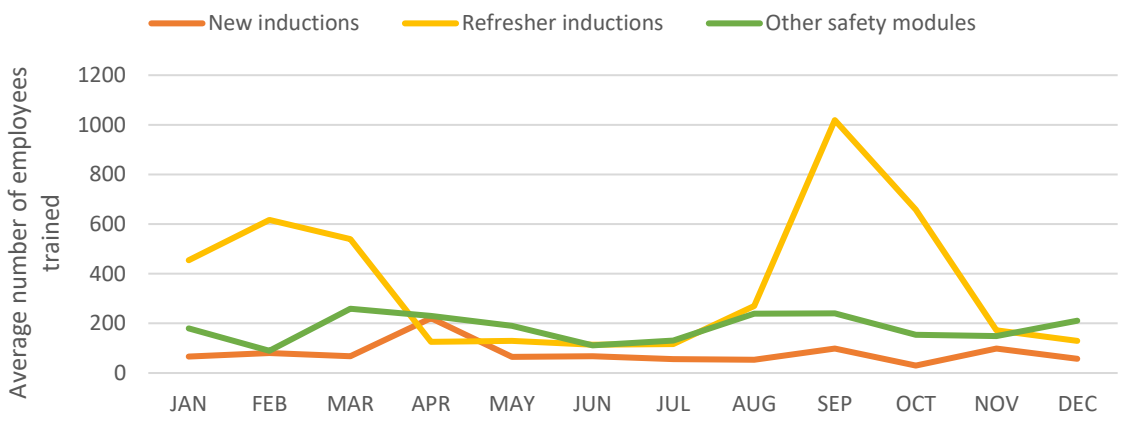

Figure 11: Monthly safety training variations

4.1.3 Correlations between training and safety

To establish the general relations between training and safety, the study examined and answered the questions shown in Table 2.

Table 2: Annual correlations between injuries and training

Question	Correlation
In each of the 4 years, is there any correlation between the total number of *new inductions* and injuries?	0.53
In each of the 4 years, is there any correlation between the total number of *refresher inductions* and injuries?	-0.86
In each of the 4 years, is there any correlation between the total number of *other safety training modules* and injuries?	0.02
In each of the 4 years, is there any correlation between the total number of *incidents reported* and injuries?	0.81

To establish the timely (monthly) relations between training and safety, the study asked and examined the questions shown in Table 3.

Table 3: Monthly correlations between injuries and training

Question	Correlation
Is there any correlation between the number of *new inductions* and injuries on a monthly basis?	0.06
Is there any correlation between the number of *refresher inductions* and injuries on a monthly basis?	0.13
Is there any correlation between the number of *other safety training modules* and injuries on a monthly basis?	0.03
Is there any correlation between the number of reported incidents and injuries on a monthly basis?	0.07

The results in Table 3 may suggest that it is not particularly important when the employees receive training but rather whether they do, in a particular year.

4.2 Qualitative Results

Reduction in the number of injuries is not the only measure of the effectiveness of training, although this is the primary measure. The effectiveness is also measured qualitatively through different methods discussed in the following sections.

4.2.1 Post Training Surveys

For every safety training given, trainees fill out evaluation surveys. These act to measure both the quality of instruction and the quality of content. Instruction quality is measured by ranking evidence of planning; willingness to help; knowledge of the material; communication skill; and enabling of interactions; from 1 (poor) to 4 (excellent). Content quality is measured by knowledge gained; application of knowledge; and usefulness of take-home materials. They are also ranked on a 1 – 4 scale. This research did not find many reports on these evaluations but those that were found provided an average of 88% and 90% for quality of instruction and content respectively.

4.2.2 Post Training Observations

Post-training observations are conducted by supervisors to observe that employees perform critical tasks safely. They also measure whether performance has improved post a safety training session. Employees are informed beforehand about when the observations will take place. Employees are then observed individually and the observer fills out a report that then gets sent back to the trainer. Trainers use these reports as qualitative feedback to measure the practical applicability of their sessions.

4.2.3 Training Needs Analysis

Training needs analysis outlines individual employees' skills needed to perform their tasks safely. Department supervisors, HSE department practitioners, and HSE trainers work together to compile a comprehensive list of pieces of training that each employee needs to undertake for each given year. These are then used to develop modules and schedule the necessary training. The training office is responsible for ensuring that by the end of each year, every employee receives the identified pieces of training. Therefore, the effectiveness of delivered pieces of training per year is measured on the bases of responding to the training needs matrix.

4.2.4 Risk Register

Risk is a product of the probability of an event and some measure, such as financial loss, of the consequences of the event. At Letseng, the risks that have the highest mine-wide ratings are vehicle collisions, flooding, and explosions. Road safety training, working and walking in wet conditions and fire safety are therefore some of the key pieces of training offered. Each of the departments also draws their baseline risk assessments and determines which safety training modules their employees will require to prepare and mitigate the identified risks. These risk matrices, therefore, inform the necessary training modules and guide the safety team in their efforts to mitigate risk.

Chapter 5: Analysis and Discussion

5.1 Safety Trends Analysis

The overall injury rate in the global mining industry has been declining in the past decade [38]. This trend has been explained by increases in technology, performance incentives and quality of employees' education and skills [28]. All these key factors have a similar increasing trend at Letseng, hence the formulation of Hypothesis 1 of the study [*Hypothesis 1: The global mining industry has seen a decline in the number of injuries from investing in technology, hiring skilled labor and adopting performance incentives. Studying the state of safety at a surface mine will reflect a similar pattern]*. However, the studied period 2015 – 2018 data shows an increasing overall trend of 7% increase in the total number of injuries, which makes Hypothesis 1 invalid.

The number of reported incidents of unsafe behaviors and conditions has been increasing (overall 5% increase in 4 years), which can mean either the employees are more risk-alert and risk-trained'; that they are more familiar with the reporting system; or that the unsafe conditions and behaviors are rising. It was difficult to determine which of the two is influencing the pattern. However, the concurrent patterns of injuries suggest that it is the former. 3% of reported incidents still results in injuries. The question then becomes, why are unsafe behaviors and conditions that are recognized, not corrected and still lead to injuries at Letseng? Since incidents reports show that employees are generally able to identify and report unsafe conditions, the increase in the number of reported incidents and injuries may be resulting from a lack of or poor responses and actions taken to mitigate identified problems.

The principle of normalization of deviance explains why employees are not taking proper corrective actions to mitigate identified risks (Mikes & Kaplan, 2012). It states that, once risks are reported, employees get a sense of completeness of action and therefore learn to tolerate them. This explains the 0.81 correlation between the number of reported incidents and injuries in Table 2. At Letseng, the reporting system allows for the allocation of the risk to a specific supervisor, which then shifts responsibility and makes corrections even slower and poorer.

5.2 Safety and Training Correlations Analysis

Hypothesis 2 established that providing annual safety training to all surface mine workers onsite improves the overall safety performance of the mine. This was formulated on change theories that recognized training as an adequate agent to influence positive change to behavioral safety. Data from Letseng mine confirmed this hypothesis. The correlation between the number of annual injuries and the number of employees who received annual refresher training is *-0.86*. To formulate hypothesis 2, we used both the Lewin's Change Model and Kotter's Eight-Step Model and identified refresher training as an ‘unfreezing’ agent. That is, training can ‘Create a guiding coalition’ between the training workers, ‘Develop a vision and strategy’ to minimize injuries, and ‘Communicate the change vision’. These met conditions qualify training as a system’s ‘change’ agent, and this is validated by data. Results even show a *-0.78* correlation between the sum of all inductions and injuries. It is, however, important to realize that when these model conditions are not met, i.e. when a coalition is not formed, safety training shows no influence on safety. This is evident in the 0.53 weak correlation between initial training and injuries. Initial training is provided to small groups of people, mostly to individuals or to groups of less than ten.

Hypothesis 3 aimed to establish the most appropriate frequency of safety trained based on learning and forgetting theories [*Hypothesis 3: Overall safety performance is higher when the number of employees recently exposed to safety training is higher].* Results from Letseng proved this invalid for all types of safety training. This is, however, a limited conclusion because the specific times of training were not found during data collection and the conclusion is based on monthly correlations between training and injuries. The data suggests that safety rules and regulations do not change fast enough to makes annual refreshers inadequate. It also suggests that it is not important how many people are trained per month, just as long as each employee receives annual training, hence establishing 12 months an arbitrary working frequency.

5.3 Analyses summary

According to organizational learning, organizational change, and organizational performance theories – the safety performance at Letseng should be improving annually, influenced by the change agent, which is training. However, data shows that performance is worsening, with a 7% average annual increase in injuries in the past four years. I believe that the site is stuck in a false confirmation circle shown in Figure 12 below.

In this circle, the company trains employees on how to 'identify and avoid' unsafe behaviors and conditions. Then, reporting of unsafe incidents increases and this confirms that people are more 'aware' and have adequate 'knowledge' of safety rules and regulations. This provides ungrounded confidence to the safety team that if more non-conformance incidents are recognized and reported, then safety will improve. The focus on employee's corrective actions is, therefore, less emphasized.

Employees find a sense of completeness of action in reporting, normalize the deviances and hence the increase in injuries. To attempt to decrease injuries, the safety team provides 'awareness' training and the circle continues.

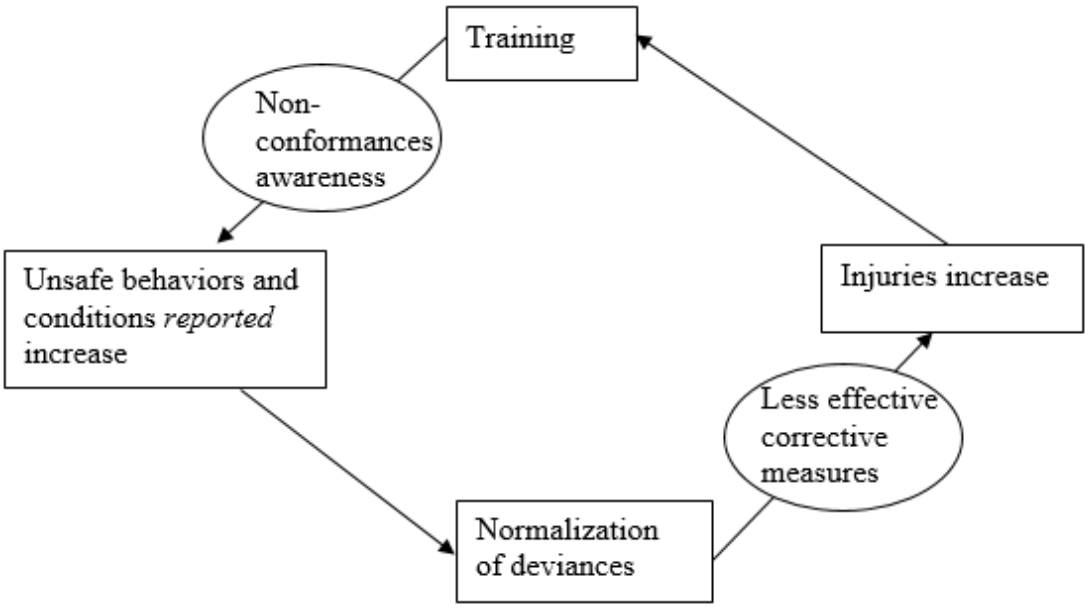

Figure 12: False confirmation circle

5.4 Recommendations

5.4.1 Create a sense of urgency for refresher training modules

Analysis of safety and training data revealed that refresher training is a variable that is most correlated to injuries. This means to reduce the number of injuries, it would be beneficial to invest in the improvement of that training. This would be in terms of the number of people re-trained, hours spend, change in material delivered and change in means of delivery. For the past four years analyzed in this study, an average of 477 employees goes without refresher training each year. Lewin's change model emphasizes the need for a complete coalition to unfreeze systems [32]. With an average of 26% of the employees left out of the training each year, it would be difficult to influence safety change. Therefore, Letseng needs to ensure that all employees receive revised quality safety refresher training each year.

5.4.2 Provide action-oriented training

Results analysis showed that employees are well-trained in identifying and reporting incidents. However, it appeared they may not have sufficient training in taking the next steps and correcting the non-conformances. A word-choice analysis of employer versus employee responsibilities outlined in training demonstrated this. Employee responsibilities key verbs include: cooperate and report, while those of employers are action verbs such as prevent, reduce and provide. Additionally, the Corrective Action Management plan places supervisors and heads of departments at the core of taking corrective actions, while employees are described as identifiers and reporters of incidents.

To move from identification of potential harm to the reduction of harmful occurrences, training needs to focus on the required contribution of employees to corrective activities, perhaps make incident reporters leaders in making sure the reported incidents are corrected.

5.4.3 Invest in a worker-focused safety plan

The current safety plan outlined in qualitative results and case study background sections is limited. It focuses on what the organization needs to do to not fail in keeping workers safe, rather than what it can do to succeed. The Harvard Business Review [40] referred to this phenomenon as the 'set-up-to-fail' syndrome. It is also known as behavior confirmation or self-fulfilling prophecy. This is reflected in the policy, the leadership engagement with employees about safety, the HIRA and BBC, and even the safety training modules. It appears that these systems are set up with a confirmed belief that workers will fail at keeping safety regulations. The policy, for instance, outlines all activities that the organization, that is the employer, represented by management, will do about safety. It states little about the employees' involvement. The leadership also commits to taking full responsibility for safety, hence their full role in taking corrective actions in non-conformities. This needs to be revised.

5.4.4 Follow the mega-trends

Although modern technology is starting to be incorporated at Letseng, most tasks are still manual. The global mining industry is striding fast into incorporating artificial intelligence, automation and data analytics to improve safety [41]. Common tasks such as HIRA could be automated to ensure that all potential hazards are recognized and not left to human subjectivity and bias.

Most road and equipment accidents could also be avoided by using modern quality monitoring systems and incorporating the internet of things technologies to analyze employees' alertness and probabilities to non-conform. In summary, Letseng can take a few important steps to achieve its safety performance goals, and in this century, incorporating technology might be one to the most effective.

5.5 Research Limitations

The main limitation of this research is its reliance on existing data. None of the data analyzed was collected first hand by the researcher. It is therefore hard to confirm its quality and therefore its appropriateness for use. For instance, there are potential human biases with the collection of both the training and the injuries data. There seemed to be consistency in the recording and management of this data for the past four studied years. However, it would be more reliable for future studies to collect the data with the aim and objectives of the studies in mind.

Because the data collection did not have the objectives of this research in context, there are limitations in the capacity of the data to reveal related variables that influence safety and training effectiveness. Multiple other factors influence safety culture, and they are outside the scope of this research due to data limitations. For instance, workers' demographics and general wellbeing are not only related to how easily they learn and return training content, but they also influence their perception of change and safety regulations. Most experienced, older workers may find it difficult to change their norms and adopt new safety standards. Different demographics can also influence employees' attitudes to the training programs. Other relevant factors include organizational structures and team dynamics. Sizes and diversity of teams can influence team

joint attitudes to safety. The influence of leadership and how management models safety are other key factors that influence safety. The scope of this research focusses precisely on the direct relationship between training and injuries and such analysis limits the capacity of recommendations.

An additional key limitation is in combining both contractor data with that of the mining company. These two groups at Letseng, are quite different in that they hold different stakes, have different safety policies and regulations and show different commitments to safety. They are usually quite different for most mines that outsource mining activities to contractors as well. However, this difference is significant for this case study as all major activities are outsourced, yet safety is not. Data used in this study are collected and managed by the Letseng safety team, which is deemed the only safety team acting on behalf of the contractors as well. To minimize the impact of this limitation on research findings, it would be beneficial to understand the individual safety strategies for each of the contractor groups and contrast that to their corresponding injury statistics.

Another limitation of this research is its analysis of a single company and mine site. This did not allow for benchmarking with companies or industries facing similar problems. Doing so could have given this study an edge and would be beneficial to consider for similar research projects. General training practices and safety policies from other mines and other industries are quoted in the literature review. However, the collection of data from another mine site could reveal the underlying safety issues that may or may not be related to training. Such parallel analysis would also reveal some of the fundamental practices or events that have shaped the safety success of

some companies. For example, in 2008 the Rustenburg Anglo-American mine in South Africa closed all operations and retrained all its 30, 000 employees to fundamentally revolutionize safety performance and safety culture. Fatality rates dropped by 62% thereafter [42]. Contrasting such training successes alongside Letseng's training program could better describe the ingredients of a good training program and should be considered for further studies of this topic.

Chapter 6: Conclusions

I. *The primary strategy for surface mines to improve safety performance is training.* In essence, maintaining employee safety is mitigating the risk of injury. This is done through HIRA by identifying the risk, assessing it and controlling for it. Training is involved in all these key steps and its effectiveness determines the success of the risk mitigation. That is why the study of the adequacy of mine safety training is both critical and timely.

II. *There is evidence to confirm that the number of people trained annually correlates to injuries incurred*. This is an important observation because as the case study revealed, some workers skip annual refresher training. It could be on the bases of individual absence, or a department skipping the training. However, with the results of this study in mind, safety departments could keep close attention to ensure that all workers receive the training at least once in 12 months.

III. *This study and its conclusive findings can be applied in mining, in other dangerous workplaces, and academia.* Most industries use training to change behavior and to influence change. It is therefore important to measure its added value. The study identified a lack of focus on corrective actions in training as the key barrier to decreasing the number of incurred injuries. The conclusion is could encourage content revision for safety training programs across the board.

IV. *Although the study showed potential in revealing insights on training and safety, it has significant limitations as well.* Its key strength is in analyzing real and specific site mining data rather than depending on published material. However, this data was collected without the bases of this research in mind, was collected by the mine safety team and not the research team, and so may have some biases and inconsistencies through the four analyzed years.

V. *Future research can use the findings of this study to determine the relevance of other components of training such as hours invested, budget and quality of instruction*. As already established, in any potentially unsafe work that involves people, training is essential. All components of it will be important to examine in the mining industry context. This study established the relative importance of the number of people trained. Future studies could use the principles of this work to establish the relevance of time, money and skill invested in training.

In conclusion, surface mines need to develop their safety strategies around strongly prepared training plans. In the age of machine learning and innovation, it is easy for mining companies to start relying on technology for their safety. However, people are at the core of the critical decision-making processes and their ability and willingness to make the right decisions are influenced by what they know and from what they have been taught. Therefore, for practical and academic reasons, it was important to know how to keep workers safe by effectively training them, hence this research.

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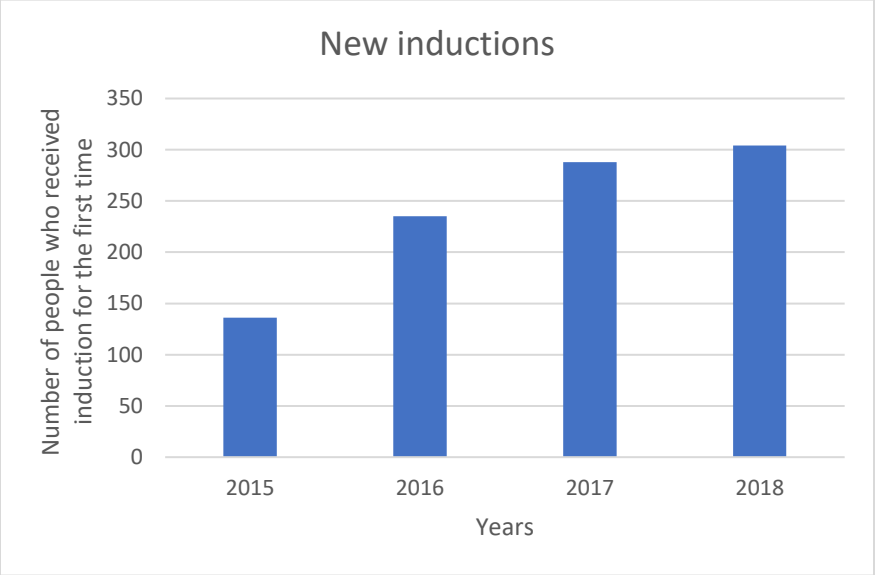
Appendices

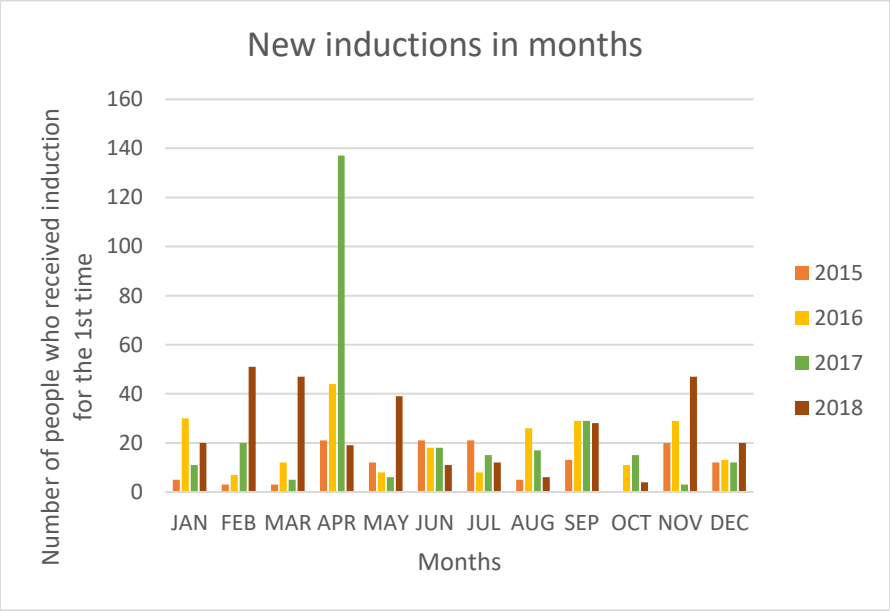
Appendix A - Training

1. List of the internally offered training

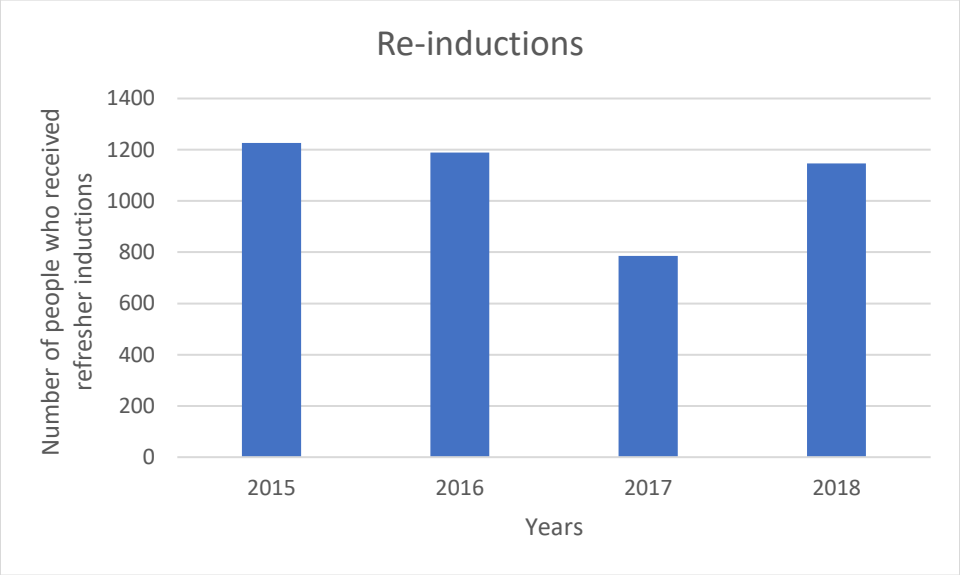
Emergency coordinators
ISO 45001 Transition
Chemical Safety
Driving Awareness and Vehicle Safety
All areas driving
BLS for Health care providers refresher
HIV & AIDS awareness
First aid level 1
First aid refresher
Motor vehicle extrication
Advanced Fire fighting
High Angle
Food safety
ISO 45001 migration
HSE Re-General Induction
Specific Personal Protective Equipment
Environmental Awareness
Post Incident Risk assessment
Working at height awareness
Management of change
Toolbox talk
Radiation Safety Awareness
Lifting and rigging
HSE Supervisors Responsibilities and Legal requirements
Life Jacket use
HSE Representatives
Permit Issuers
Hazard Identification and Risk Assessment
Incident Reporting
Personal Protective Equipment
Right to refuse unsafe work

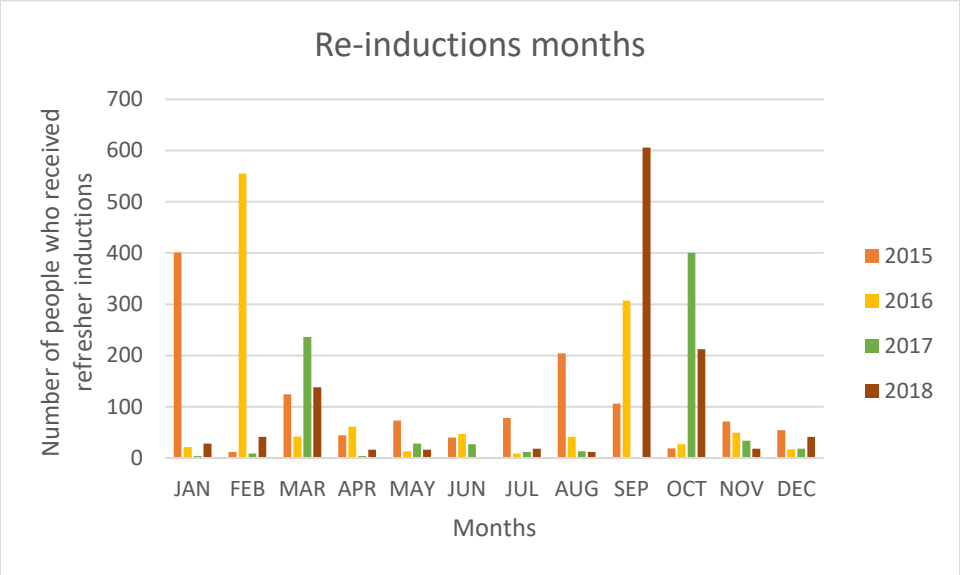
2. New inductions



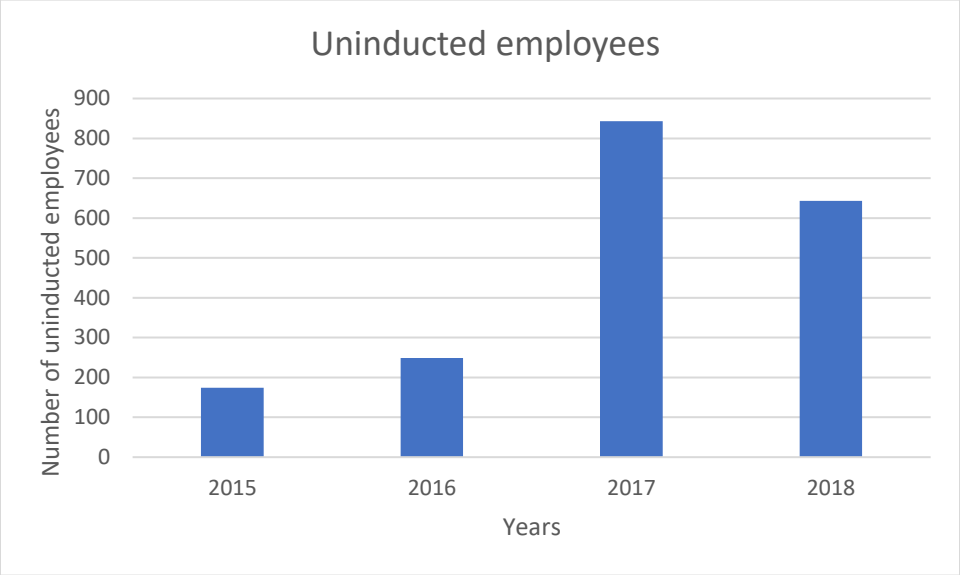


3. Re-inductions

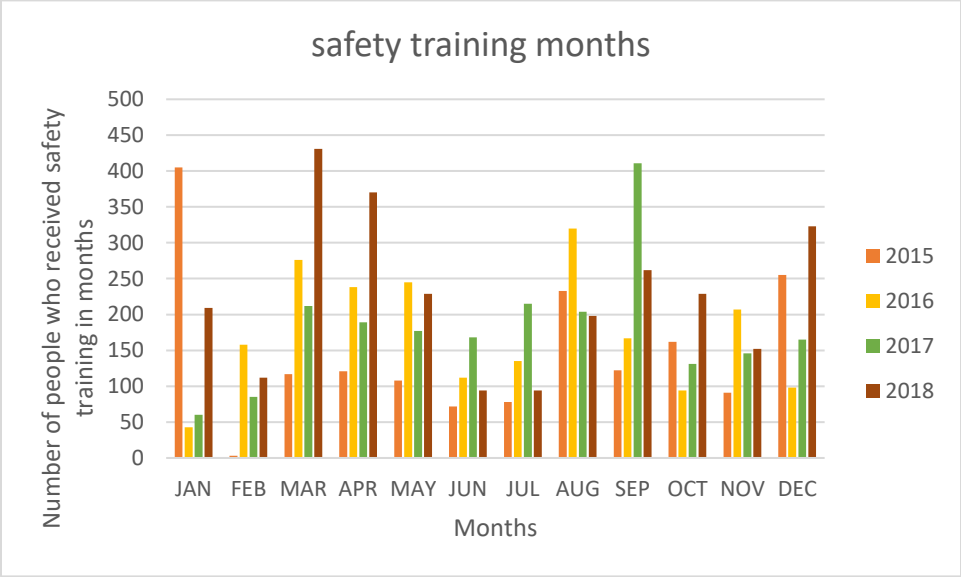




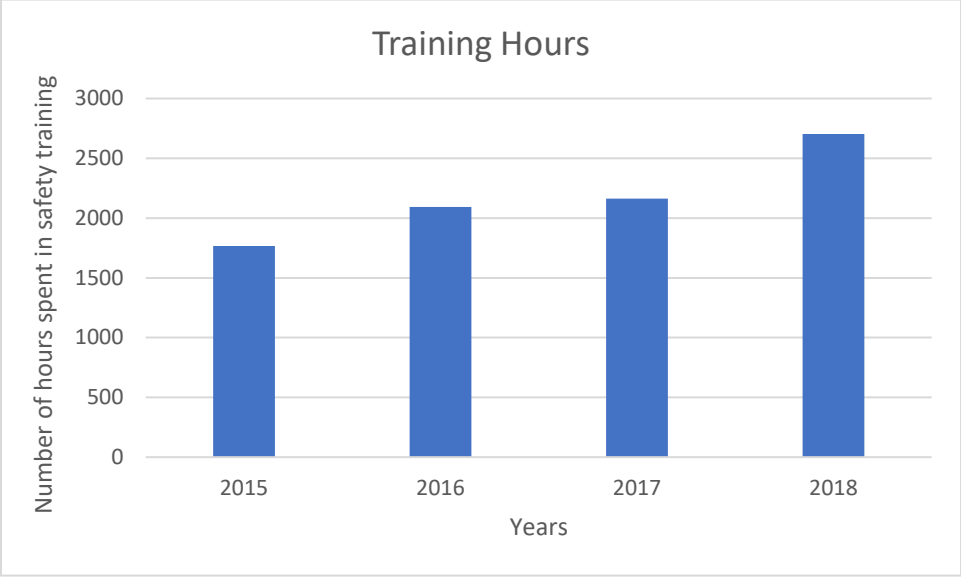
4. Employees who do not receive annual refresher induction

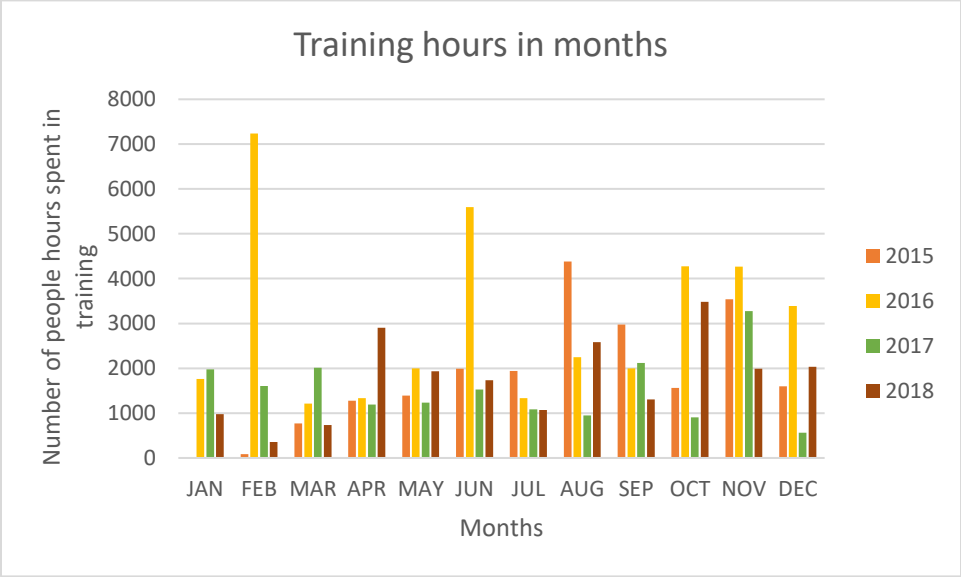


5. Safety Trained people



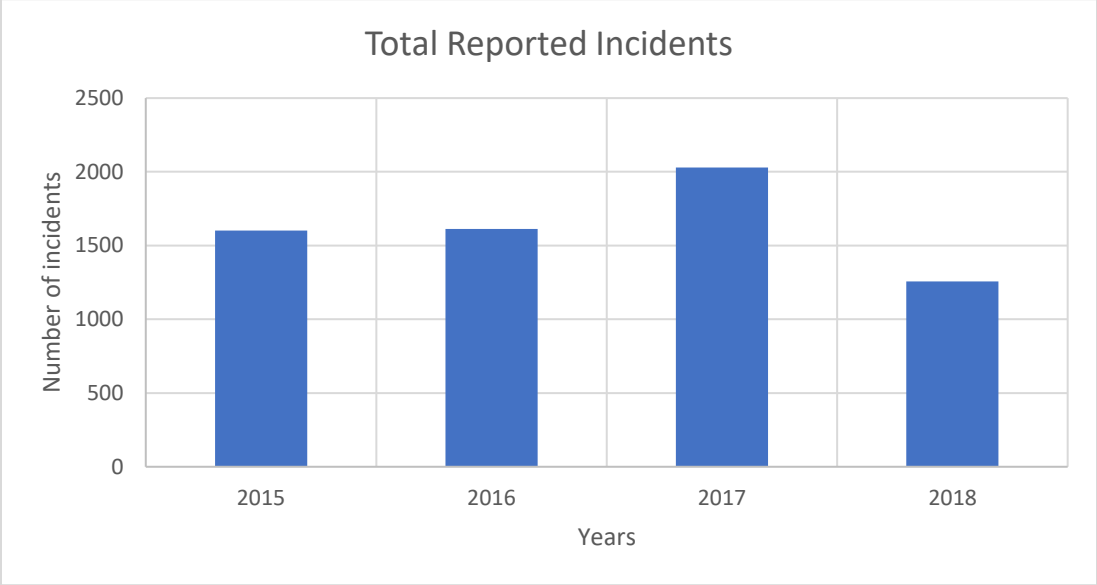
6. Safety Training Hours

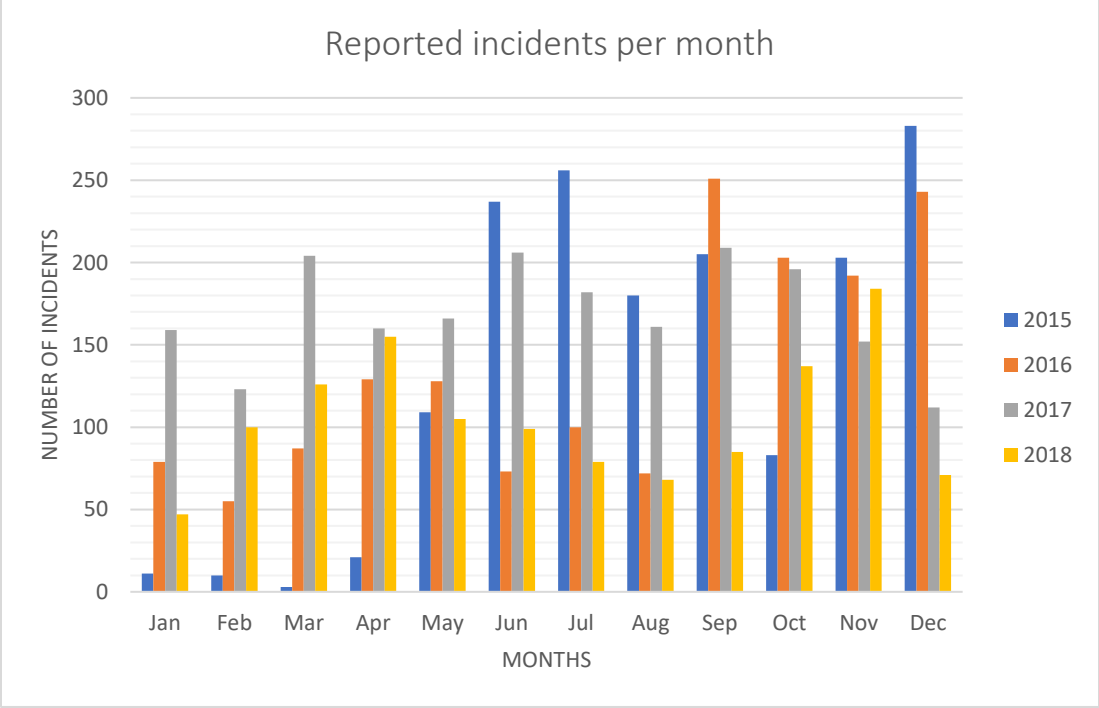




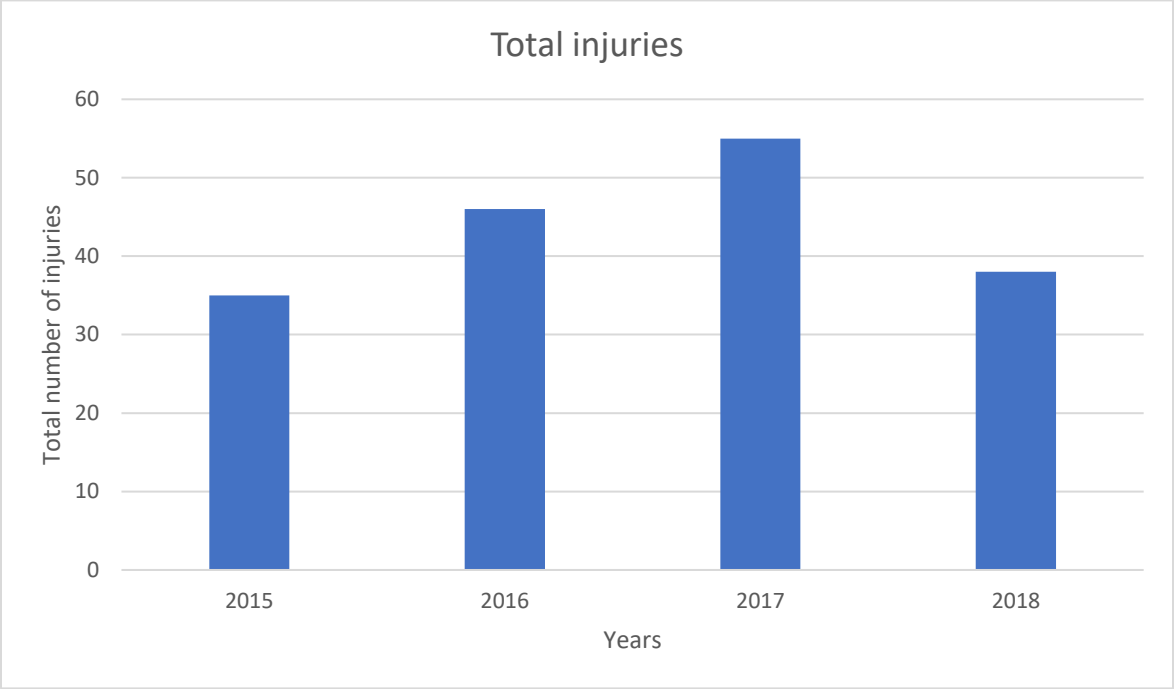
Appendix B - Incidents and Injuries

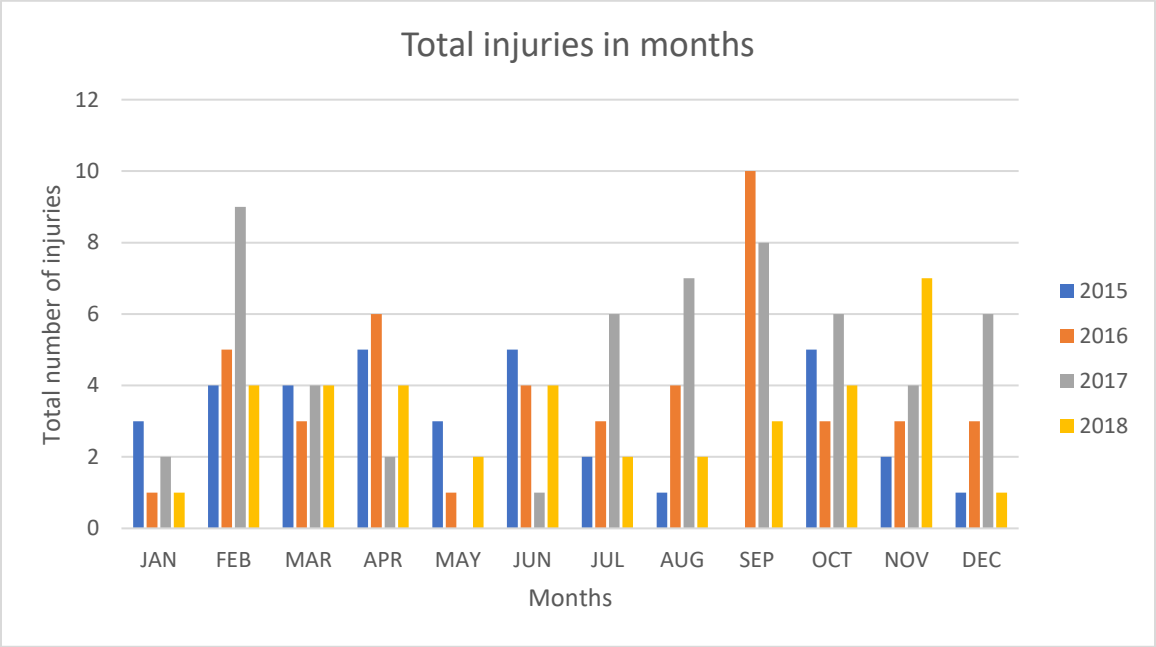
1. Total incidents reported



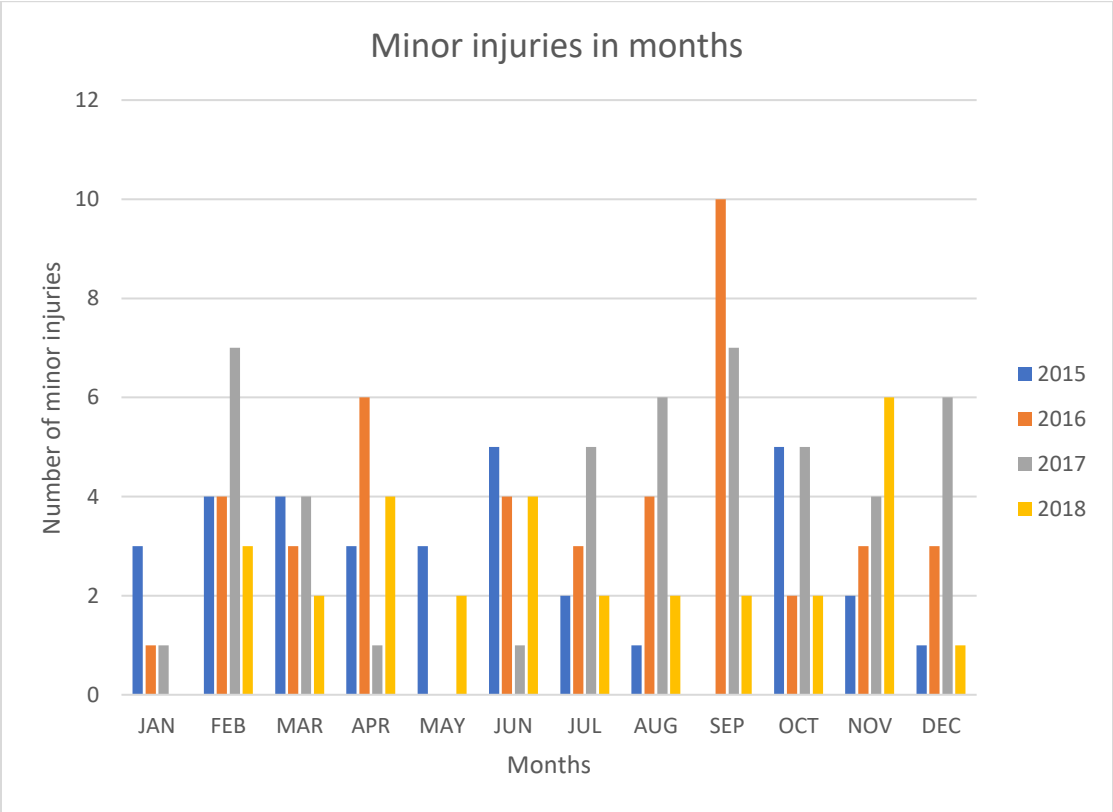


2. Total Injuries

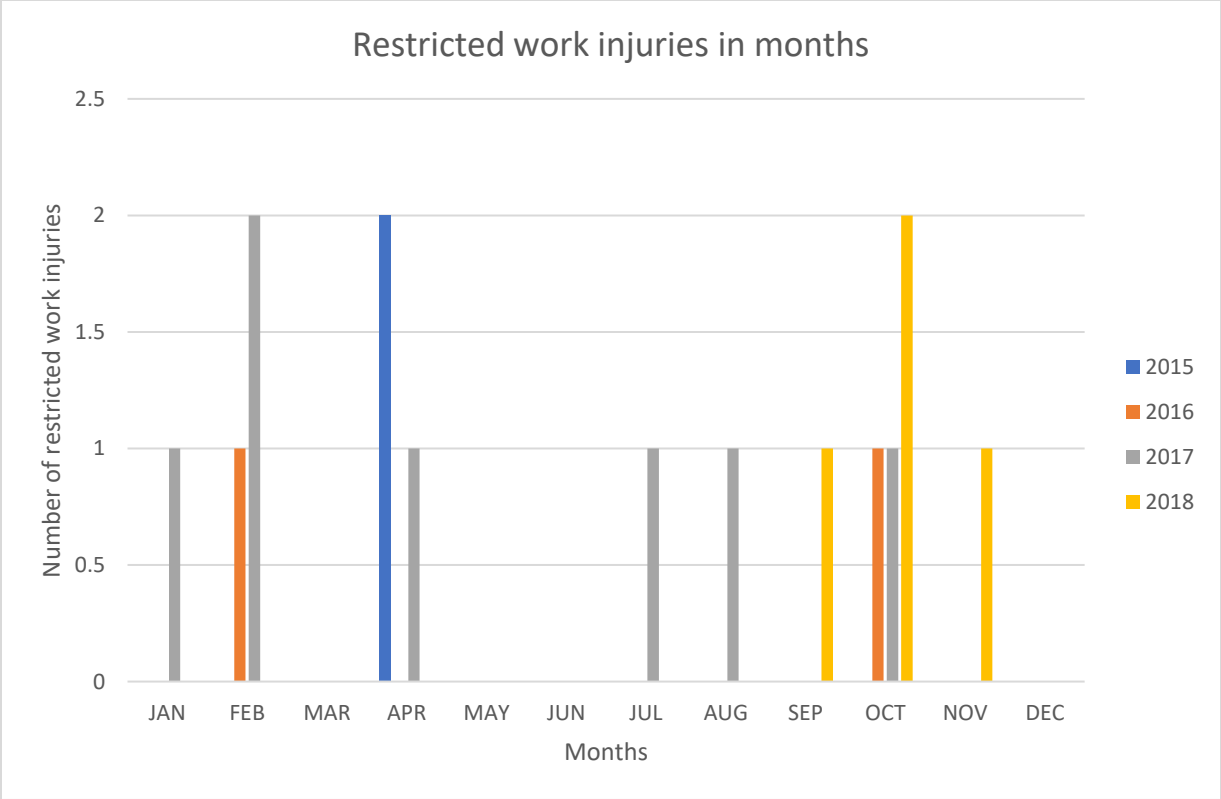




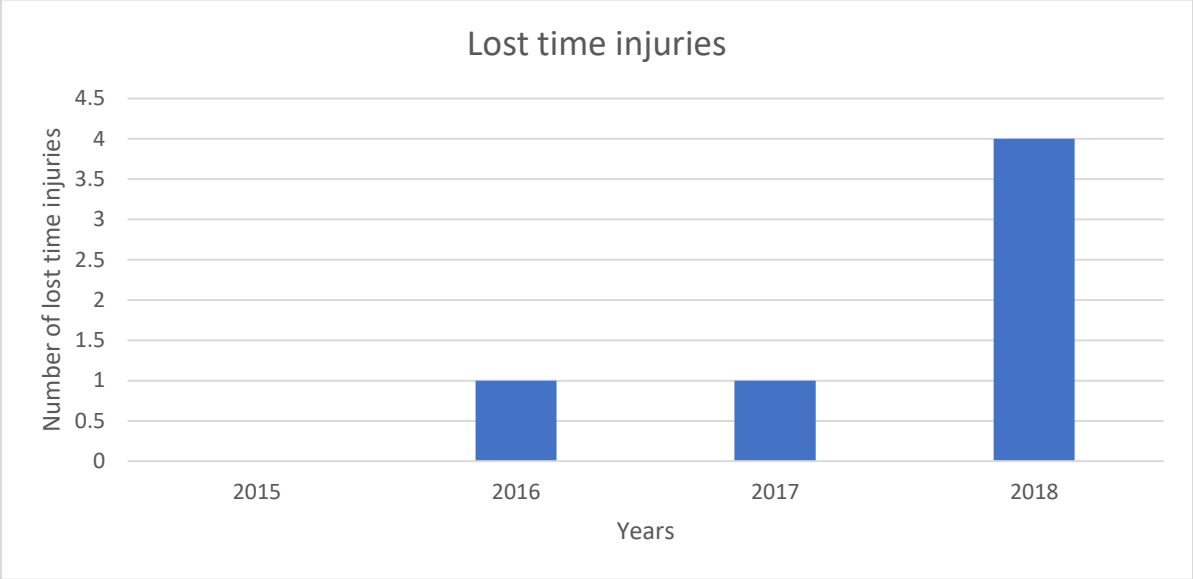
3. Minor Injuries

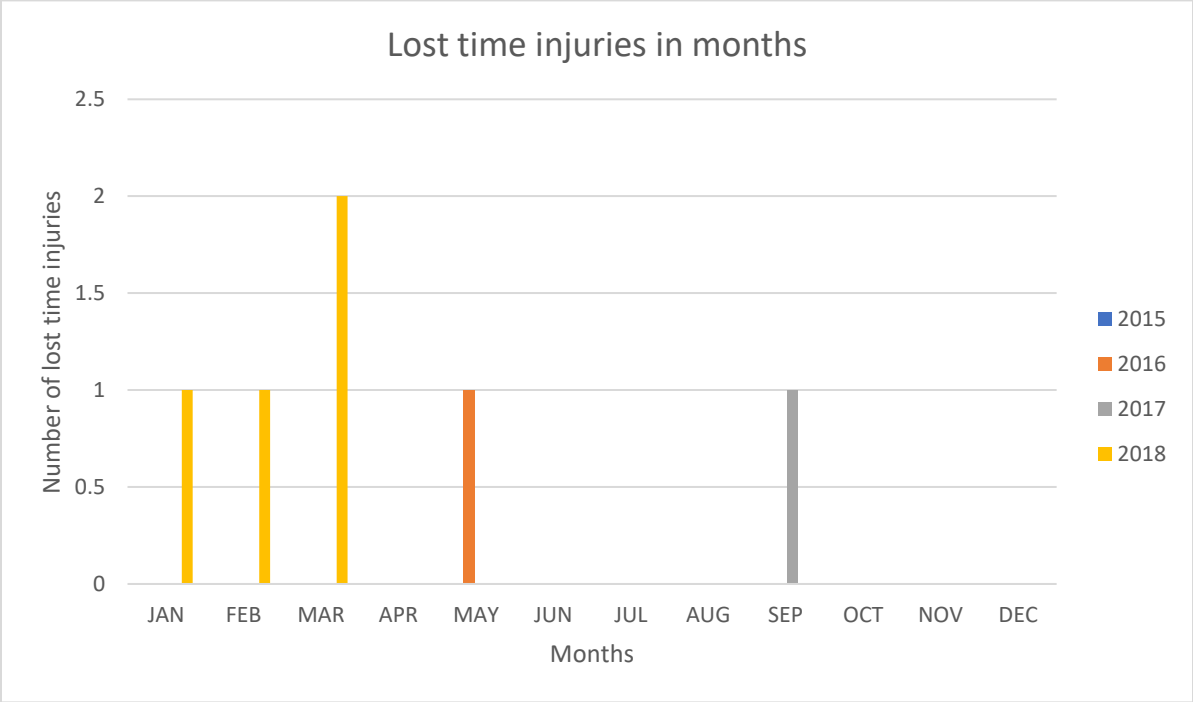


4. Restricted Work Injuries



5. Lost Time Injuries

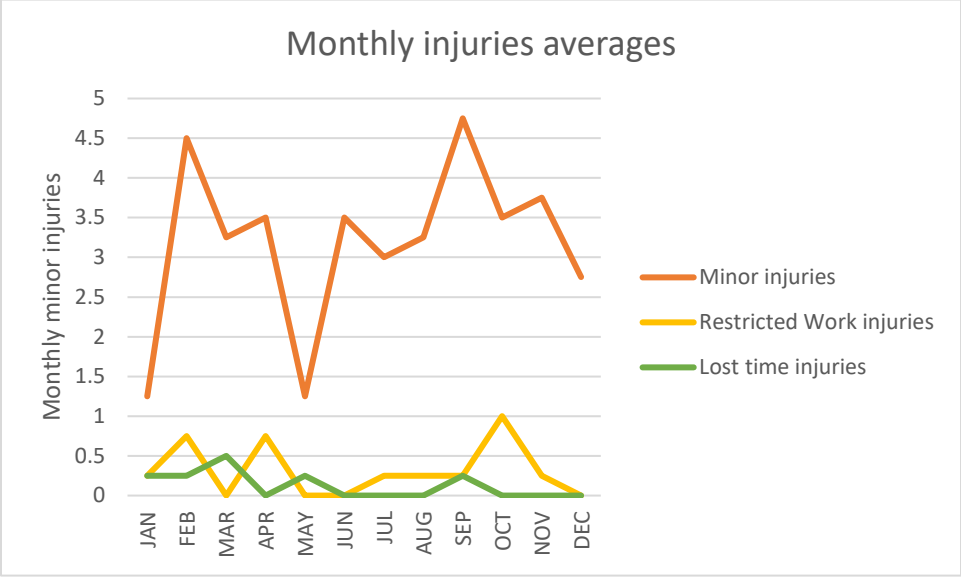


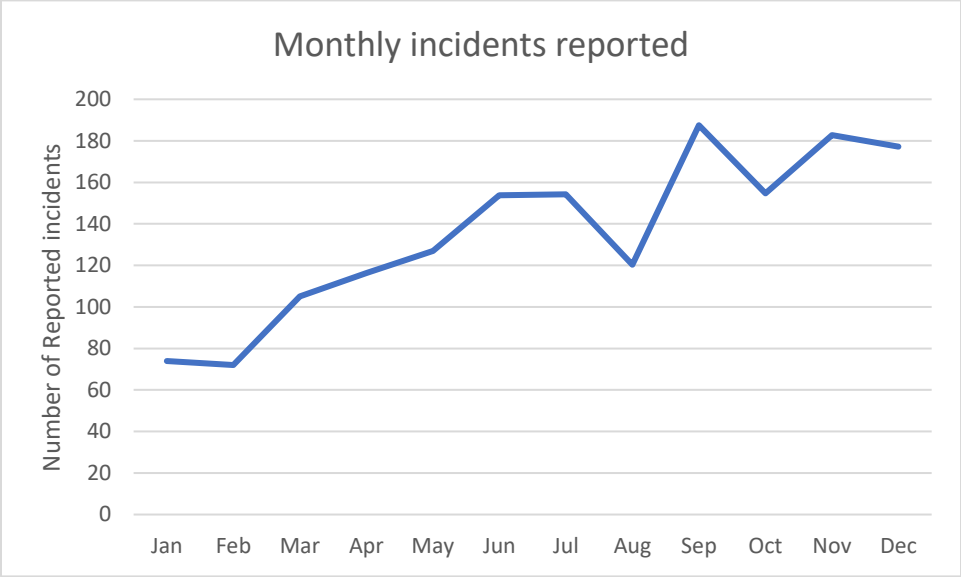


6. Fatalities

Zero fatalities in 2015/16/17/18. One fatality in 2019

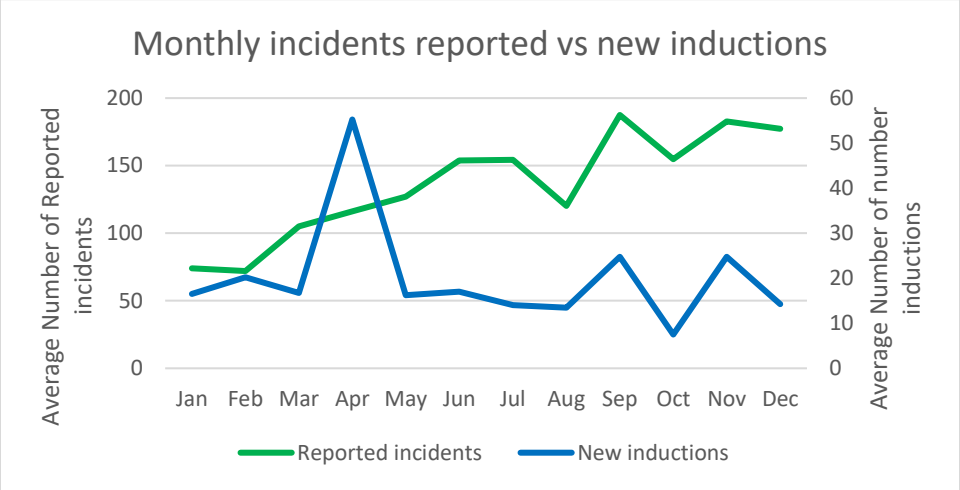
7. Monthly Averages

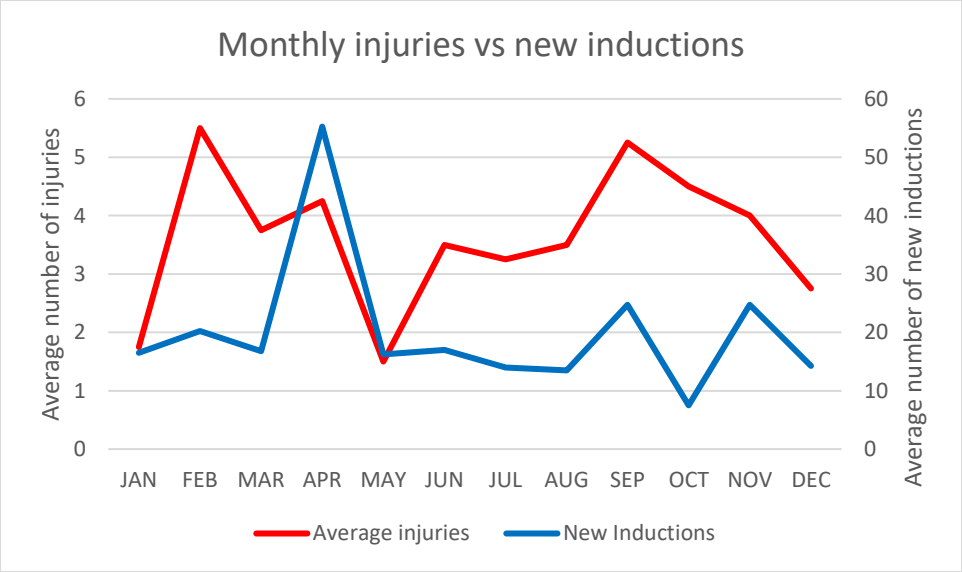




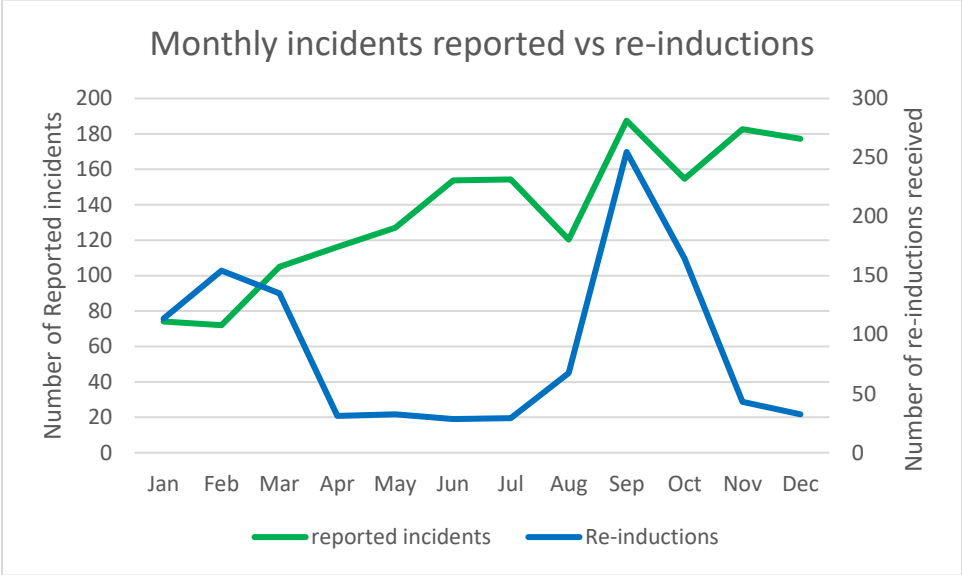
Appendix C - Training and Incidents Correlations

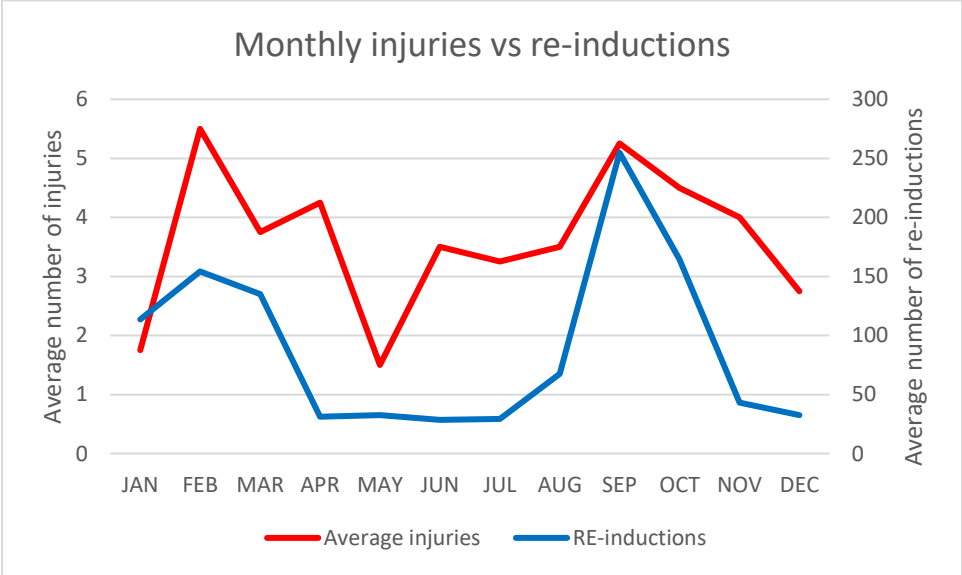
1. New inductions vs training



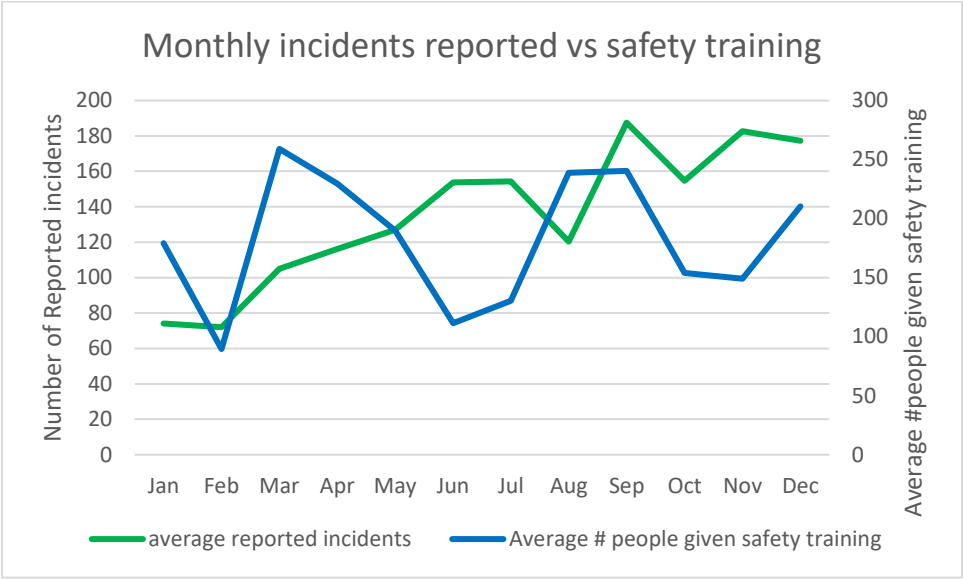


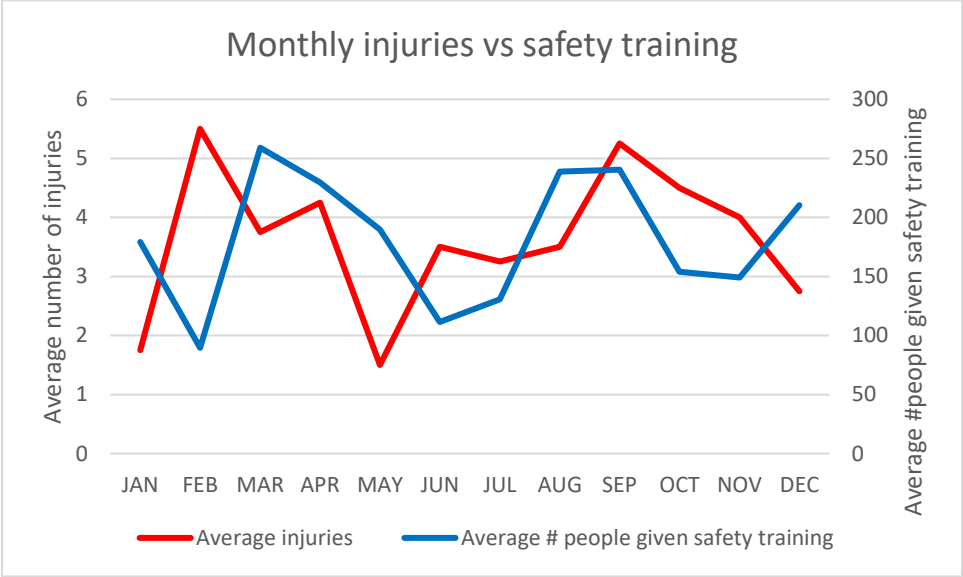
2. Re-inductions



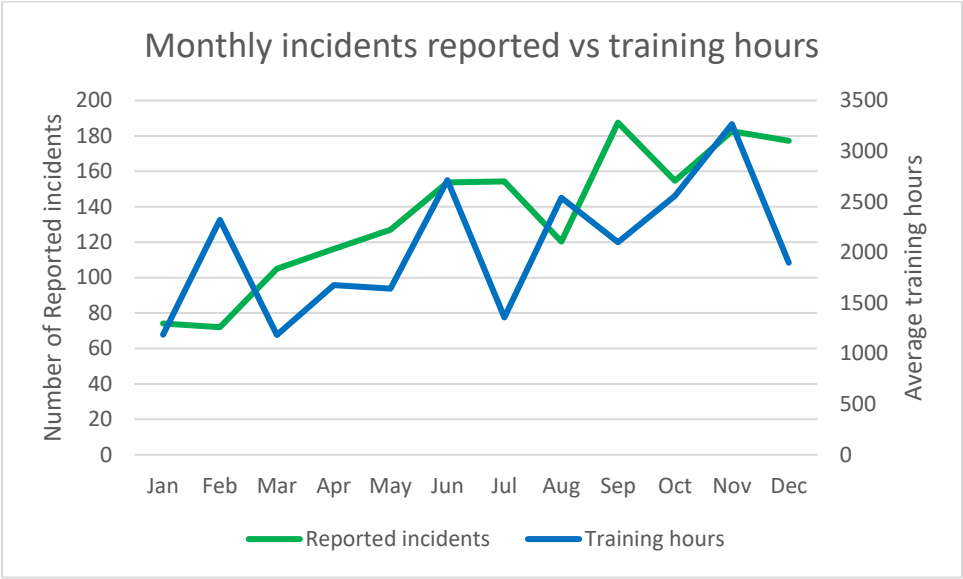


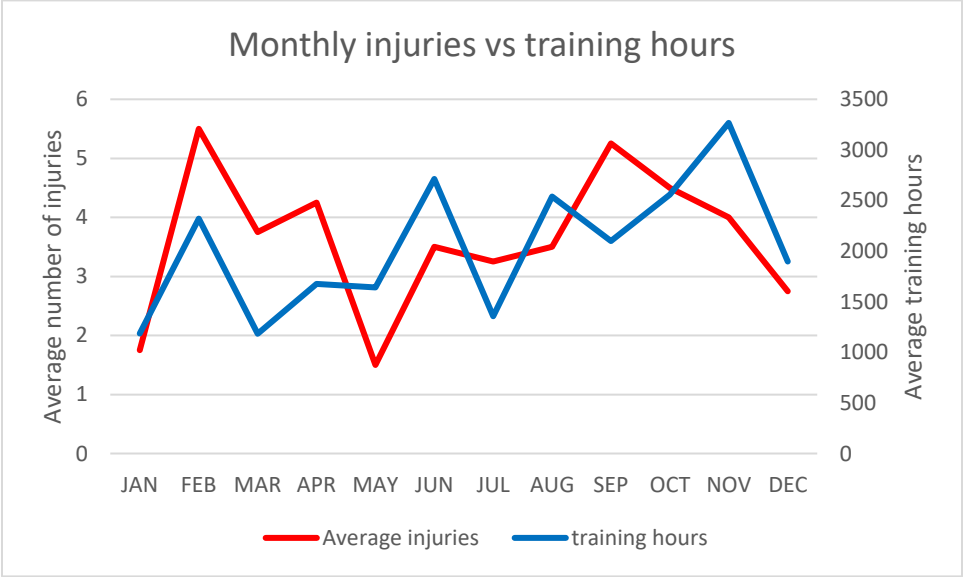
3. Safety training number of people





4. Safety training hours





5. Data correlations coefficients [Overview]

	New Inductions [Number of people]	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
1	2015	5	3	3	21	12	21	21	5	13	0	20	12	**136**
	2016	30	7	12	44	8	18	8	26	29	11	29	13	**235**
	2017	11	20	5	137	6	18	15	17	29	15	3	12	**288**
	2018	20	51	47	19	39	11	12	6	28	4	47	20	**304**

Annual Total Correlations	
1 and 4	0.53
2 and 4	-0.86
3 and 4	0.02
5 and 4	0.81

	Re-inductions [Number of people]	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
2	2015	401	12	124	44	73	40	78	204	106	19	71	54	**1226**
	2016	21	555	42	61	13	47	9	41	307	27	49	17	**1189**
	2017	4	9	236	4	28	27	12	13	0	400	34	18	**785**
	2018	28	41	138	16	16	0	18	12	606	212	18	41	**1146**

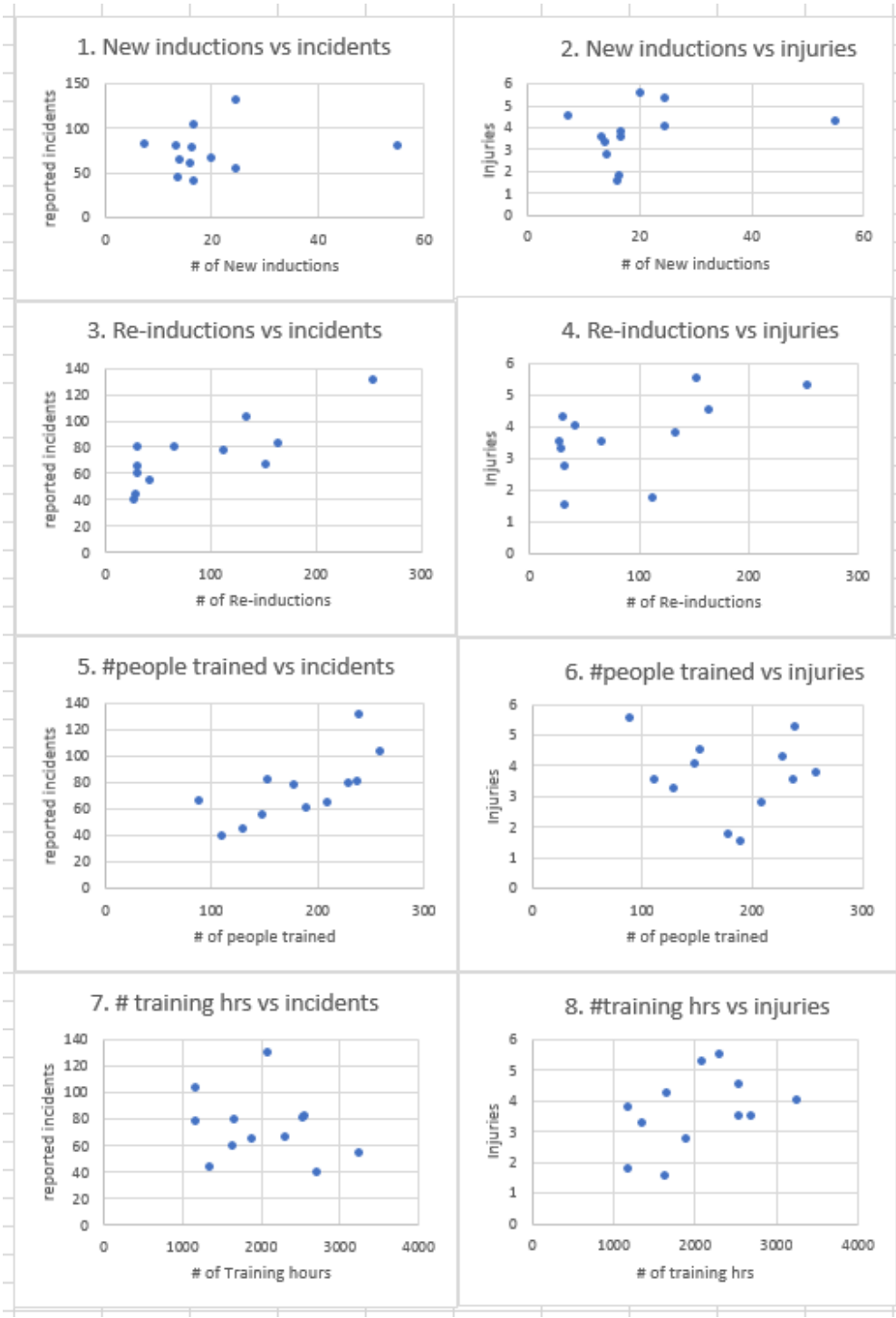
Monthly Correlations	
1 and 4	0.06
2 and 4	0.13
3 and 4	0.03
5 and 4	0.07

	Other safety training [Number of people]	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
3	2015	405	3	117	121	108	72	78	233	122	162	91	255	**1767**
	2016	43	158	276	238	245	112	135	320	167	94	207	98	**2093**
	2017	60	85	212	189	177	168	215	204	411	131	146	165	**2163**
	2018	209	112	431	370	229	94	94	198	262	229	152	323	**2703**

	Total injuries	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
4	2015	3	4	4	5	3	5	2	1	0	5	2	1	**35**
	2016	1	5	3	6	1	4	3	4	10	3	3	3	**46**
	2017	2	9	4	2	0	1	6	7	8	6	4	6	**55**
	2018	1	4	4	4	2	4	2	2	3	4	7	1	**38**

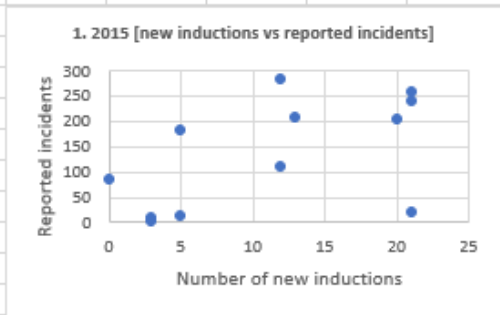
	Incidents reported	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
5	2015	11	10	3	21	109	237	256	180	205	83	203	283	**1601**
	2016	79	55	87	129	128	73	100	72	251	203	192	243	**1612**
	2017	159	123	204	160	166	206	182	161	209	196	152	112	**2030**
	2018	47	100	126	155	105	99	79	68	85	137	184	71	**1256**

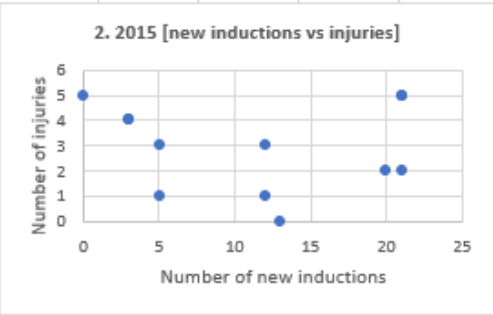
6. Data Correlation coefficients – Four years averages



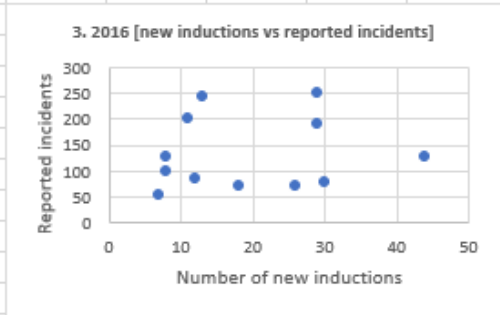
Graph	Data Correlation
1	0.15
2	0.27
3	0.81
4	0.57
5	0.71
6	-0.12
7	-0.22
8	0.44

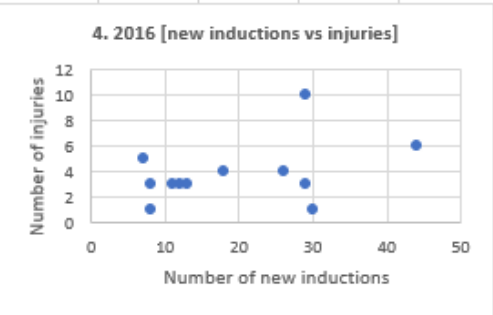
7. Data Correlation coefficients – Annual analysis for new inductions

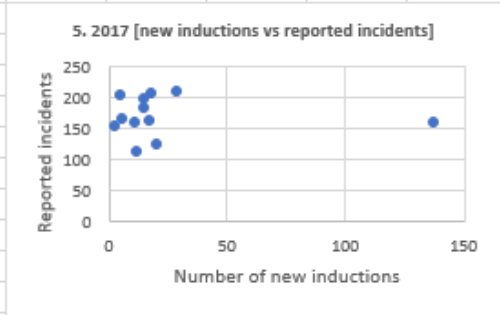


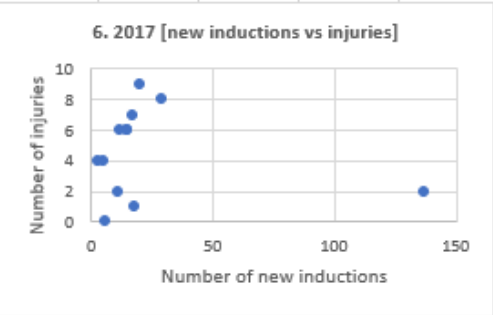


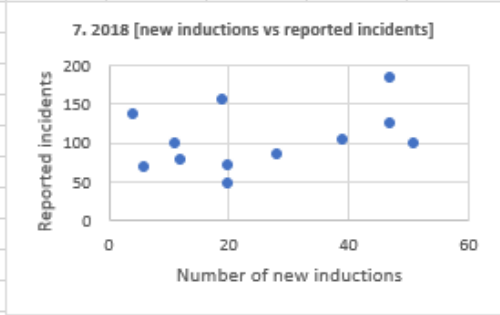
Graph	Correlation
1	0.54
2	-0.08
3	0.13
4	0.39
5	-0.05
6	-0.17
7	0.36
8	0.42

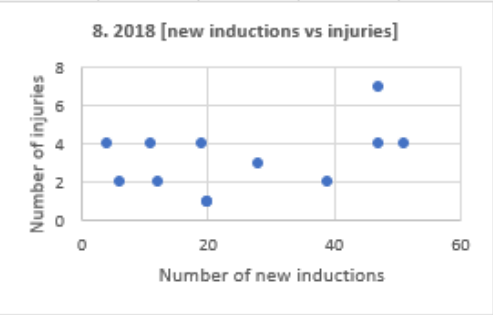




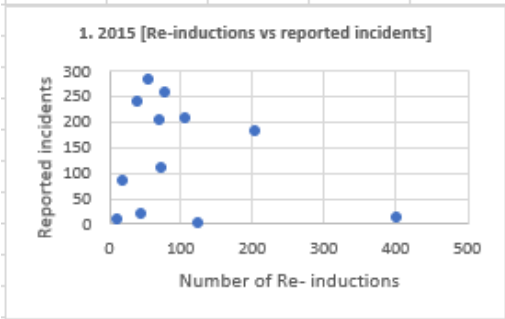


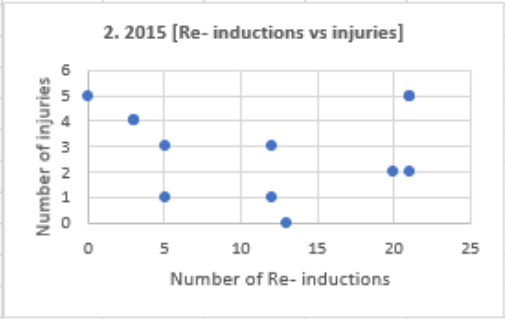




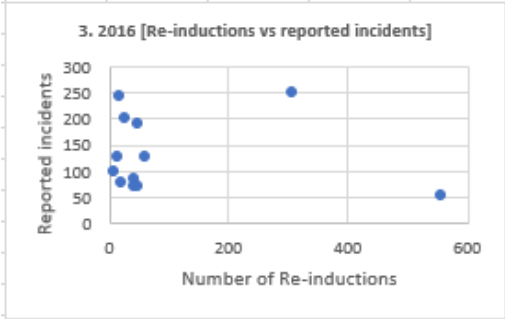


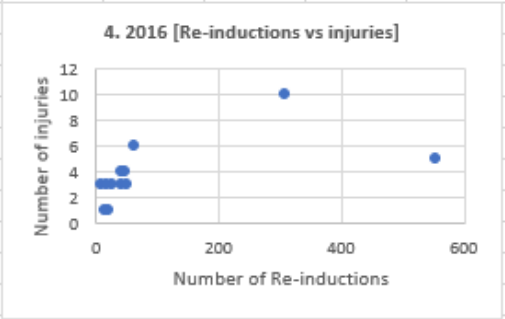
8. Data Correlation coefficients – Annual analysis for re inductions

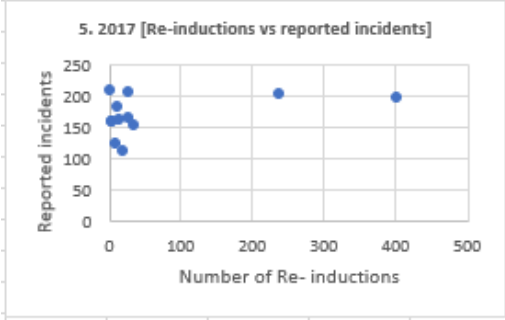


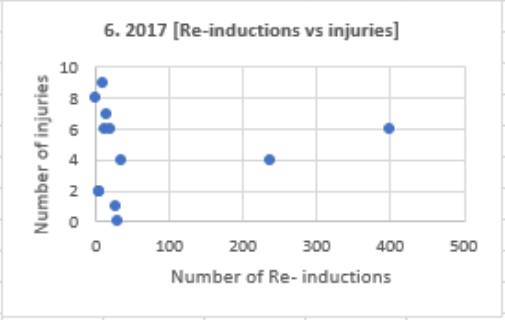


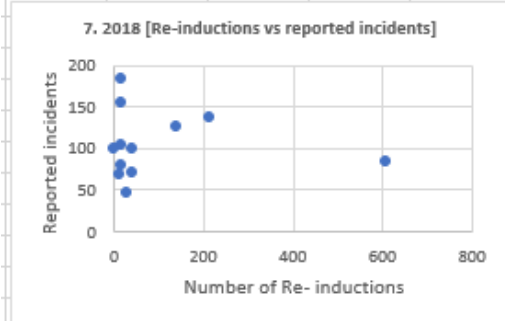
Graph	Correlation
1	-0.24
2	-0.26
3	-0.09
4	0.57
5	0.41
6	0.07
7	-0.05
8	0.03

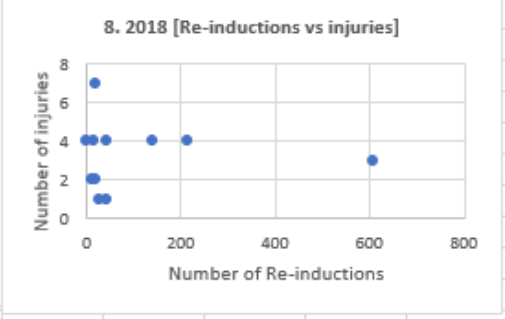




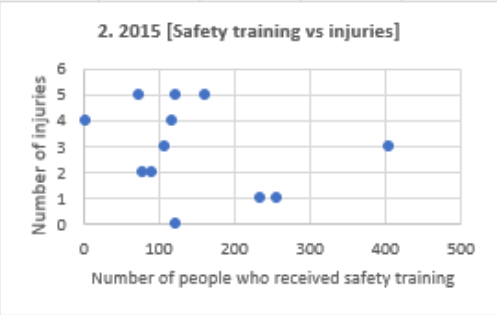




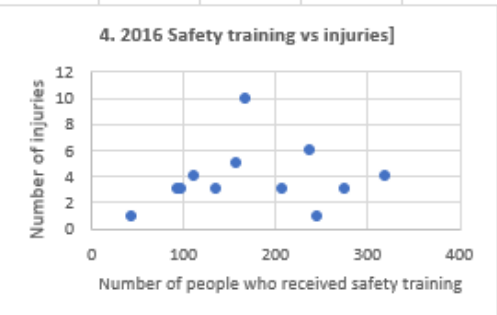


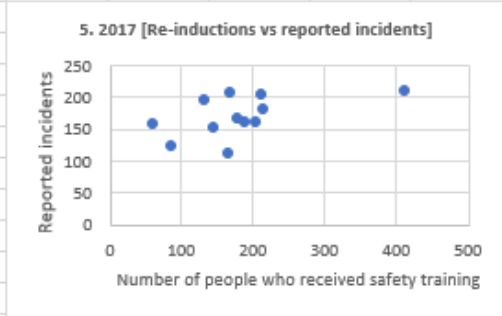


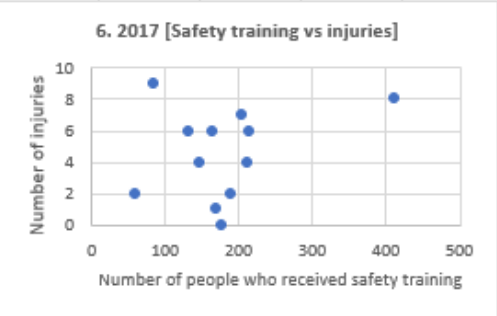
9. Data Correlation coefficients – Annual analysis for safety training

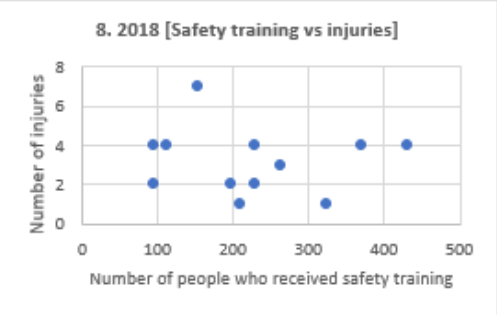


Graph	Correlation
1	-0.07
2	-0.26
3	-0.21
4	0.14
5	0.52
6	0.27
7	0.18
8	-0.10









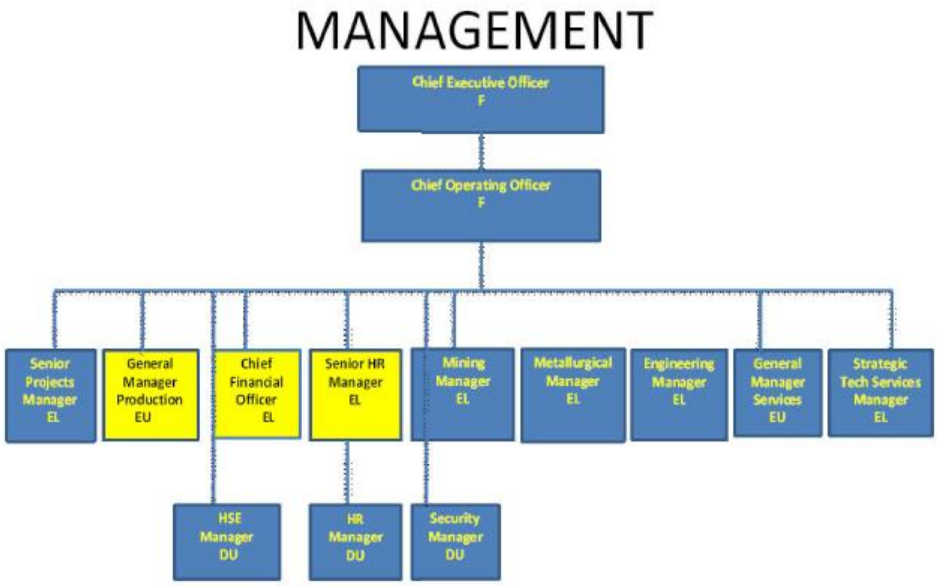
Appendix D - Safety Strategy Subjects and Employee Profile

1. HSE 2018 Policy

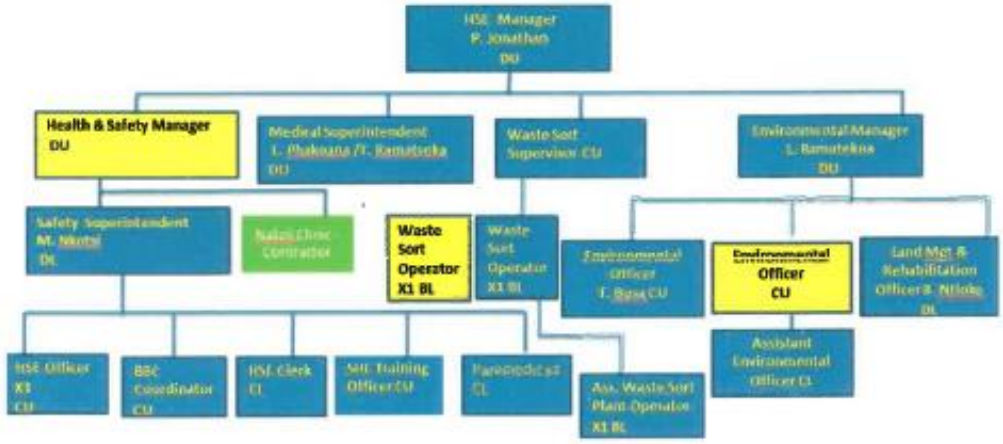
TO REALISE THE ABOVE COMMITMENTS, WE UNDERTAKE TO

- Develop, implement and maintain a management system for Health, Safety and Environment to eliminate hazards, reduce HSE risks and impacts and prevent pollution.
- Implement and maintain Behaviour Based Care (BBC), Hazard-Aspect Identification and Risk-Impact Assessment (HIRA) Programmes to advance the prevention culture.
- Investigate HSE issues to determine the root-causes and opportunities hence prevent recurrence of undesirable HSE incidents and to inform resources conservation initiatives.
- Comply with applicable HSE legislation, regulations, relevant other requirements and standards, and adopted best practice.
- Involve employees and their representatives to gain commitment to the implementation of HSE initiatives and the exchange of information through HSE committees.
- Provide information, instruction, training and supervision to make workforce conversant with inherent risks and develop people by providing necessary resources to meet targets.
- Provide a framework for setting and reviewing HSE objectives.
- Communicate with and encourage the workforce and suppliers to take responsibility for meeting the requirements of this policy.
- Ensure appropriate conduct of the Mine's personnel towards the Project Affected Communities (PACs), respecting their human and traditional rights at all times.
- Monitor and report on performance to stakeholders as required.
- Ensure the suitability of this policy to the organisation and review it annually or as dictated by changing conditions and requirements.
- Maintain continual and sustainable improvement.
- Make this policy available to all stakeholders.

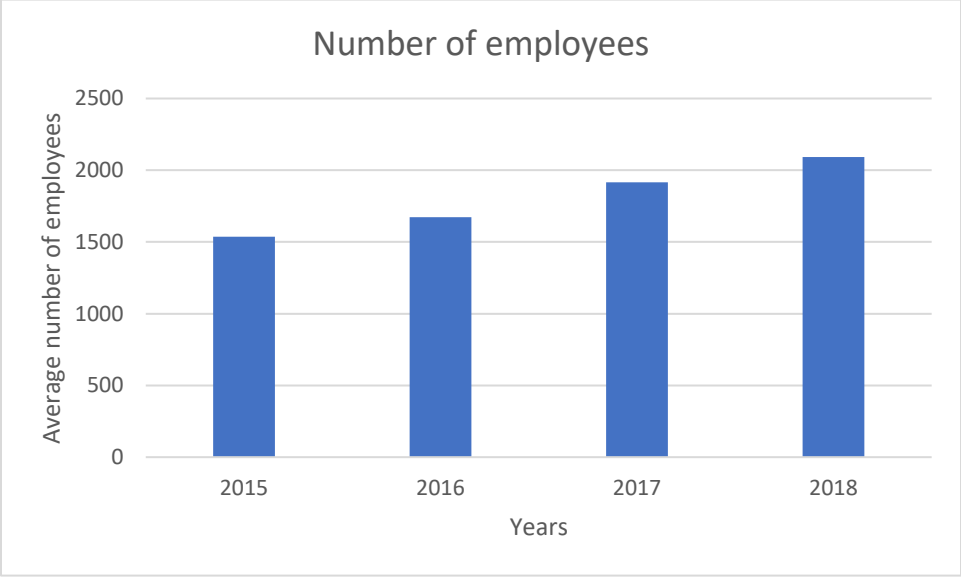
2. Organograms

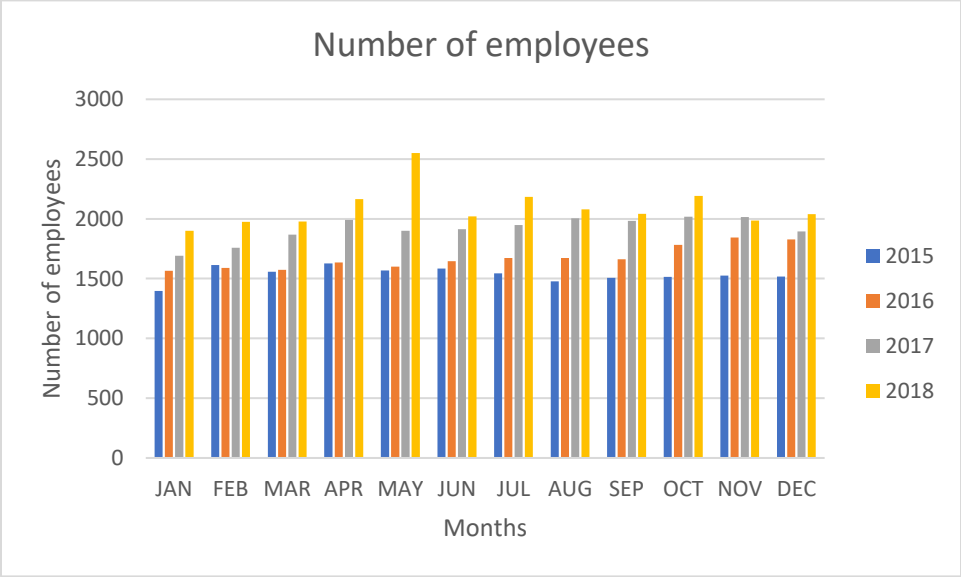


Health Safety & Environment

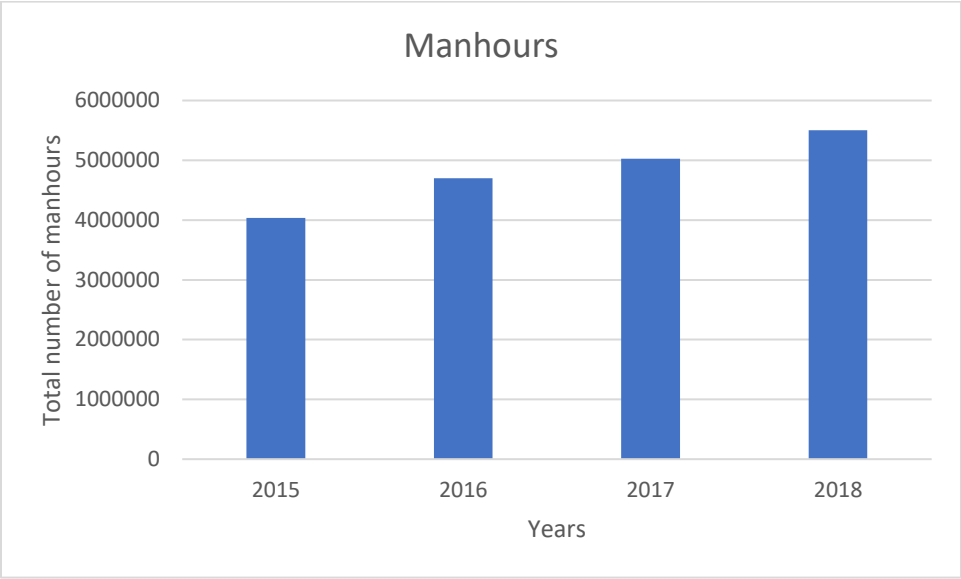


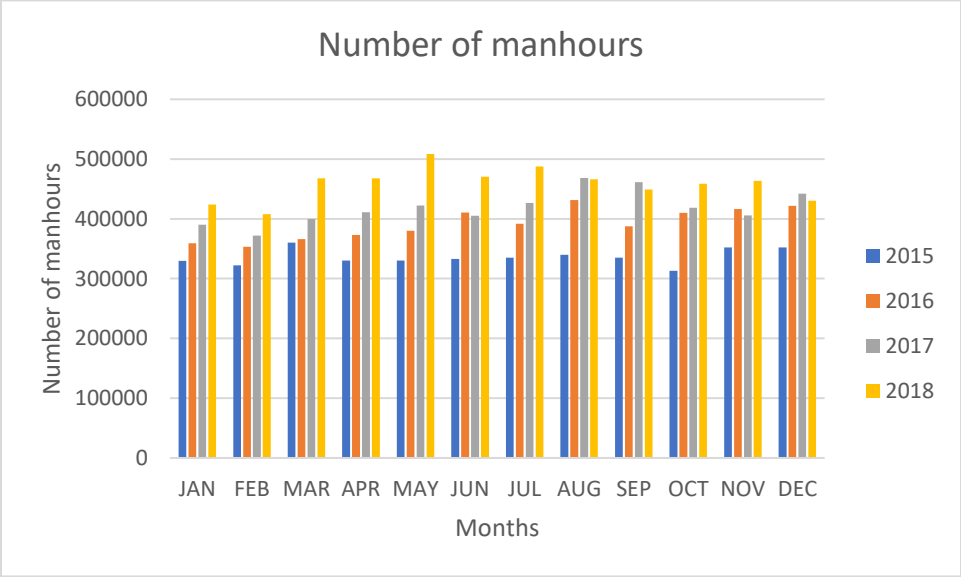
3. Number of employees





4. Manhours


Manhours
6000000
5000000
4000000
3000000
2000000
1000000
0
Total number of manhours
2015
2016
2017
2018
Years


Number of manhours
600000
500000
400000
300000
200000
100000
0
Number of manhours
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
Months
2015
2016
2017
2018

5. Staff Demographics

Group staff demographics (%)

Employee level	% male	% female	% local citizens	% age <30	% age 31 to 50	% age >50
2018						
Governance Committee Board*	**100**	**0**	**25**	**0**	**55**	**0**
Senior management	**89**	**11**	**83**	**6**	**50**	**44**
Middle management	**82**	**18**	**87**	**7**	**77**	**16**
Total workforce	**80**	**20**	**96**	**12**	**76**	**14**
2017						
Governance Committee Board*	100	0	26	0	41	59
Senior management	92	8	69	0	46	54
Middle management	78	22	84	1	81	18
Total workforce	81	19	97	14	74	12

** Includes subsidiaries.*

https://www.gemdiamonds.com/downloads/2019/reports/gem-diamonds-annual-report-final.pdf