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Assessing and Optimizing Safety Operations in Mining: A Case Study of a South African Mine

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Abstract

Effective safety operations are essential in the mining sector, where poor safety practices increase operational risks and hinder performance. This case study investigates the impact of poor safety operations on organizational performance at a South African mine using an exploratory sequential mixed methods approach. Initial observations were followed by quantitative analysis of historical safety records, with qualitative insights reinforcing the findings. The findings revealed widespread noncompliance with safety protocols, poor communication practices, and a weak safety culture, all contributing to frequent incidents and over 200 hours of operational downtime. Key recommendations include continuous safety training, clear-standard operating procedures (SOPs), frequent safety audits, and a safety-first cultural makeover. Implementing these measures is expected to reduce incidents, enhance productivity, and improve organizational performance.

Keywords
Safety operations, Regulatory standards, Organizational performance, Safety culture, and Compliance.

1. Introduction
The mining industry is an integral part of South Africa's economy; in 2023, it was estimated that the sector contributed around R400 billion to South Africa's Gross Domestic Product (Minerals Council South Africa 2023). From an employment perspective, the sector made a substantial contribution to job growth by creating more than 450,000 direct jobs and numerous indirect vocations. The vast bulk of minerals are mainly designated for export markets. The aggregate worth of exports in 2023 was R575 billion (equivalent to around US$31 billion), making up about 58% of the country's total exports during that period. This surge was largely driven by strong demand for coal, platinum, and iron ore (PwC South Africa 2023; Seamaster Maritime & Logistics 2023). The aforementioned statistics emphasize the crucial significance of mining in the economic framework of South Africa, therefore emphasizing the importance of efficient and safe mining operations (Minerals Council South Africa 2023). With safety hazards presenting a substantial threat to personnel, equipment, and productivity, the mining sector is intrinsically dangerous (Wang et al. 2024). Despite developments in technology and safety standards, mining accidents and deaths continue to occur, underlining the necessity for continuing examination and improvement of safety operations. Numerous safety related incidents have occurred in the South African mining sector, underscoring the necessity for continuous evaluation and improvement of safety procedures (Department of Mineral Resources 2024).

However, challenges persist, and non-compliance and inadequate enforcement of safety operations remain a significant concern. The industry's safety record is marred by incidents of rockfalls, explosions, and equipment failures, resulting in loss of life and injury to employees (Kolapo et al. 2022). Furthermore, the psychological and socio-economic impacts of these incidents on employees, families, and communities are significant (De Jager 2019). Therefore, it is imperative that mines adopt a proactive and holistic approach to safety management, incorporating robust risk assessment, continuous training, and employee engagement to prevent accidents and ensure a safe and healthy work environment (Singo 2022).

1.1 Problem statement

The occurrence of safety-related incidents in mining, stemming from poor safety operations, is a major concern that at times can be fatal. In 2022, Africa accounted for the highest number of fatalities, accounting for 14 (43%) reported fatalities, followed by South America with 9 (27%), North America with 4 (12%), Asia with 4 (12%), and Oceania with 2 (6%) of the total. Mobile equipment accidents (27%), fallen objects (15%), working at heights (12%), and other causes (46%), were reported to be the primary causes of these fatalities (International Council on Mining and Metals 2022). Safety is of the utmost importance in mining operations, and mining companies are at risk of suspension or substantial penalties if they fail to adhere to safety regulations.

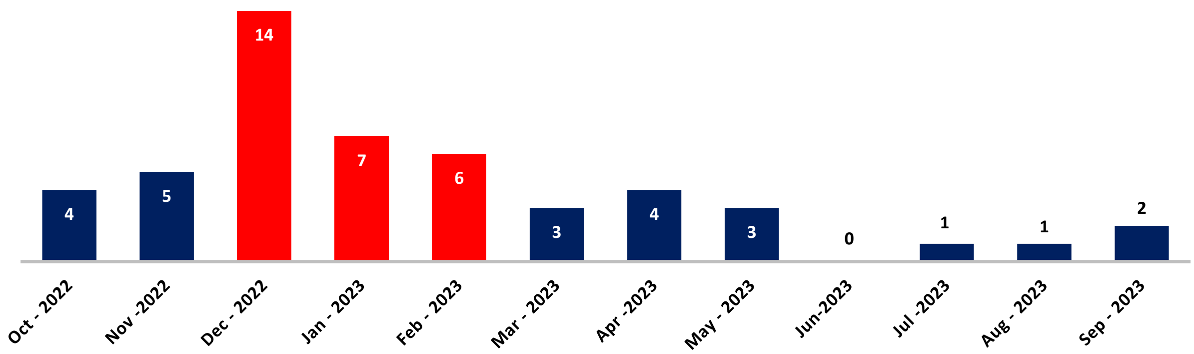

Figure 1. XYZ Mine Incident Trend

The Executive Committee (EXCO) at XYZ Mine observed a troubling trend concerning the high rate of incident occurrence at the mine. Figure 1 illustrates the monthly breakdown of safety incidents, revealing the safety challenges faced throughout the year. December had the highest rate of incidents, as the mine experienced a total of 14 incidents. This was followed by January with 7 and February with 6, respectively. The consistent monthly occurrence of incidents throughout the 12-month period highlighted a poor safety culture that did not comply with safety measures, putting daily operations and contractual commitments at risk. The executive committee believes this stems from the poor safety operations carried out at the mine. This gap highlighted the need to scrutinize the mine's safety operations and validate the executive committee's statement. Therefore, this study was conducted to assess the safety operations at the Mine to offer recommendations aimed at optimizing the safety operations and organizational performance.

1.2 Aim, Objective and Questions of the study

This study aims to assess safety operations at XYZ Mine in order to identify the root causes of safety incidents and propose actionable solutions to reduce their occurrence, thereby improving organizational performance. To achieve the aim of the study the following specific objectives (SO) have been established: (SO1) To identify the root causes of safety incidents; (SO2) To examine the impact of safety incidents on organizational performance; (SO3) To develop tailored solutions for reducing safety incidents and improving organizational performance.

In alignment with the specific objectives, the study seeks to answer the following research questions (RQ): (RQ1) What are the root causes of safety incidents? (RQ2) How do these incidents affect organizational performance? (RQ3) What tailored strategies can effectively reduce safety incidents and enhance organizational performance.

1.3 Scope, Limitations, and Significance of the Study

This study aims to assess the safety operations of an open cast mine in Northwest South Africa, with the goal of providing recommendations to reduce operational downtime and enhance overall organizational performance. To achieve the research objectives, the study will examine and evaluate both primary and secondary data. The study is limited to XYZ mine and its unique operational context, safety operations, and regulatory standards. As a case study, the findings are tailored to the safety operations of the mine and may not be generalized to other safety divisions or mining operations. Further research would be required to adapt the proposed solutions to other organizations.

The mine faces significant safety challenges, making this study critically important. The significance of the study to the mine is that it identifies the underlying causes of insufficient safety operations and offers evidence-based solutions to resolve these issues. As safety plays a key role in mining operations the study aims to build evidence-based strategies that enhance safety operations, reduce operational downtime, and boost overall organizational performance. The systematic approach of the study and its findings will be highly valuable to researchers and academics who are interested in occupational health and safety and the broader mining industry. They can study and adapt these insights to their own contexts. As previously stated, mining plays a key role in a nation's GDP and employment. But the sector is also linked with a great risk of accidents and fatalities, which causes operational downtime and lost production. With this regard, XYZ mine is not an exception. The mine faced safety-related issues throughout the year highlighting the need for a comprehensive assessment and targeted interventions.

2. Literature Review

The mining sector's inherently high-risk nature makes safety paramount. Insufficient safety operations can have severe consequences, including accidents, injuries, and fatalities (Gul 2018)**.** Reducing these hazards and guaranteeing a safe workplace highly depends on a good safety management system. A robust safety culture and proactive risk management aid to reduce unanticipated interruptions (e.g., accidents or equipment breakdowns) that might otherwise stop production (Identec Solutions 2024; Mboye 2015). Chi and Lin (2022) claim that Robust safety management systems (SMS) are essential in reducing incident rates in mining operations**.** By using structured procedures for risk identification, assessment, and control, these systems reduce the probability of accidents.

Recent studies conducted in South Africa highlight how well SMS works, especially in high-risk settings like mining. De Jager (2019) highlighted the critical role of SMS in improving safety outcomes, demonstrating that its implementation in South African gold mines significantly reduced workplace accidents. Similarly, recent studies (Ehiagwina et al. 2022; Thirumalai et al. 2021) have emphasized the use of a hybrid fault tree and bow-tie model to diagnose mining incidents' root causes, highlighting the importance of systematic methods in root cause assessments. An expert research on Canadian mines indicated that introducing lean safety measures, such as 5S housekeeping and Total Productive Maintenance, increased daily mining advance rates and reduced accident risks (Nemati 2019; McKinsey & Company 2022). A poll at a South African mining corporation found that emphasizing on safety leads to increased production, with respondents agreeing that "safety improves productivity"(Mboye 2015). In summary, well-managed safety systems and processes decrease downtime and inefficiencies, allowing for smoother operations and increased productivity.

Hou et al (2021) and Paais et al (2020) identified that safety incidents were not just isolated occurrences; they exert a direct and profound impact on organizational performance. These incidents lead to operational downtime, financial losses and reduced productivity. Their research further underscores the critical role that leadership and organizational culture play in fostering a safer working environment. Similarly, Ismail et al (2021) and Tetzlaff et al (2021) argue that continuous safety training, supported by strong leadership, is essential for embedding a safety-first culture in the mining sector. Their study in South African mines showed that targeted safety training programs not only improved worker safety but also reduced the overall incident rates. Leadership commitment was identified as a key factor in fostering a proactive safety culture, as leaders who prioritize safety influence the entire organization to adopt safer practices (Surehire 2023). Moreover, cultural shifts within organizations can significantly impact safety outcomes. Ismail et al (2021) observed that changes in the safety culture in South African coal mines led to improved safety performance. These cultural shifts often involve moving from reactive to proactive safety practices, where potential hazards are identified and addressed before they result in incidents.

Finally, the financial implications of safety-related occurrences must be considered. Research conducted by Abd Karim and Sejati (2021) and Hadi and Nayeri (2023) shows that investing in safety minimizes incident occurrences while also improving overall operational efficiency and profitability. Companies that emphasize strongly on safety frequently experience a reduction in downtime and related expenses, resulting in improved financial performance. Workplace accidents as a result of poor operational safety impose significant costs on organizations. According to a NIOSH research, the median economic cost of a mining death is $1.42 million, which includes missed productivity, medical, legal, and other expenditures (NIOSH Mining Program 2020). Even non-fatal injuries result in medical bills, compensation payouts, equipment damage, and missed work time. These "visible" expenses are frequently supplemented by hidden costs such as incident investigations, retraining, and lost knowledge. From 2008 to 2017, U.S. mining deaths cost more than $550 million, highlighting the significant economic impact of inadequate safety measures (NIOSH Mining Program 2020).

3. Methods

This study utilized a sequential mixed-methods design, grounded in a case study approach. The methodology consisted of two clearly defined stages. Phase one encompassed the collection and examination of qualitative data, whilst phase two comprised of the collection and analysis of quantitative data. Following the completion of both phases, the researcher integrated the qualitative and quantitative data to establish a thorough comprehension of the study (Harrison et al. 2020). By incorporating qualitative insights with the quantitative results, the study achieved a nuanced interpretation of the data. This integration added context and depth to the quantitative findings, providing a richer understanding of the research topic.

3.1 Research Paradigm

This study adopts a pragmatic research approach. This approach is usually employed when a study addresses real-world problems and provides actionable solutions (Biesta 2021). The study aims to assess safety operations at the Mine with the intention to offer tailored solutions aimed at reducing safety incidents therefore enhancing organizational performance, which aligned well with the research paradigm.

3.2 Research Design:

The study employed an exploratory sequential mixed- methods approach, integrating qualitative and quantitative data to deeply understand the safety operations at the mine, as recommended by Creswell et al (2006)**.** This approach is utilized in cases where relying just on quantitative data alone is insufficient to fully understand complex problems (Creswell et al. 2006). The research design consisted of two phases:

The qualitative phase: This initial phase of the study involved in-depth site visit in the form of observations at the mine. The aim of the observations was to gain first-hand insights into the safety operations, obstacles and safety incidents encountered at the mine. The quantitative phase: This phase of the study focused on analyzing the historical safety records of Mine to identify trends and patterns, thereby quantifying the impact of safety operations on organizational performance. This mixed-methods approach allowed for a comprehensive understanding of the complex factors responsible for the high rate of safety incidents and their impact on organizational performance. The inclusion of the case study enhanced the specificity and practical significance of the findings, therefore making the findings directly applicable to address the safety challenges encountered at the mine.

4. Data Collection

The study commenced with the collection of qualitative data. The data was obtained by conducting direct observations of the safety operations at the mine. The observations took place between October 1, 2022, to September 30, 2023, comprehensive notes were taken to document safety practices and apparent noncompliance. This approach enabled the collection of rich, firsthand data that informed the foundation of the research. After the collection of the qualitative data, the study then commenced with the extraction of quantitative data in the form of historical safety records from the mines database. The data covered the period of October 1, 2022 to September 30, 2023 ensuring a comprehensive dataset for analysis. It is crucial to emphasize that the study exclusively utilized existing historical records for quantitative analysis. The study did not collect new quantitative data, therefore eliminating the need for surveys and questionnaires.

A fishbone analysis, also known as an Ishikawa diagram, is a valuable problem-solving tool used to systematically identify the root causes of a problem (Coccia 2020)**.** The study utilized this tool to systematically identify the root causes of the safety issues at the mine. This was achieved through the "5 Ms & E" of effective root cause analysis which comprise of "Methods, Machines, Materials, Manpower, Measurement and Environment. The Fishbone session was conducted as a brainstorming session that involved all the relevant stakeholders from each department of the mine. During the brainstorming session all participants brainstormed and mapped out the potential causes of the high rate of safety incidents at the mine in order to get to the root cause of the issue.

The data collection process for the study involved the following steps:

1. Planning and Authorizations: Prior to conducting the site visit the researcher drafted a plan outlining the observation protocols and obtained authorization from the Mine's management, ensuring that the data collection process was authorized.
2. Site Visit: The researcher conducted the observations, capturing valuable insights into the safety operations of the mine.
3. Historical Data Extraction: Historical safety records were extracted from the mines database.

4. Data Cleaning: To ensure a reliable and accurate analysis the collected data was cleaned to address any inconsistencies such as missing values, duplicates or discrepancies.

4.1 Sampling

The study did not involve sampling in the classical sense, as it did not attempt to infer the findings to a larger group or make generalizations about a broader population. In this case the study examined the entire population of interest (all safety operations and records during the specified period) rather than selecting a representative sample, thereby eliminating the need for sampling. As a result, the entire scope of safety operations and historical safety records at the mine during the specified 12-month period (October 2022 to September 2023) constitutes the total population of interest. This approach allowed for a complete and holistic understanding of the safety dynamics at the mine during that period.

4.2 Data Analysis

The mine's historical safety records were analyzed using Microsoft Excel. Descriptive statistics and data visualization techniques were employed to uncover trends and patterns within the data. By corroborating the observational insights with the historical findings, the analysis aimed to quantify the impact of safety operations on organizational performance. The study was reliable in the sense that if the same methodology was used in a different mine, the mine would yield consistent results for that specific context. Triangulation increased the validity and reliability of the findings by utilizing data from numerous sources. This was accomplished by using qualitative data to corroborate with the quantitative findings, thereby strengthening the reliability of the conclusions drawn.

5. Results and Discussion

5.1 Findings from the site visit to XYZ mine

The site visit observations revealed numerous breaches of safety protocols at the mine, highlighting a concerning disregard for safe operations and regulatory standards, key findings were as follows:

1. Non-Compliance with Safe Operations: Operators were seen using their mobile devices while operating the payloaders, therefore presenting a significant risk to both themselves and others.
2. Inconsistent Toolbox Talks: Toolbox talks were not conducted on a consistent basis which was a major concern as these talks are essential for sharing safety information, discussing potential hazards, and reinforcing best practices among the operators and maintenance personnel.
3. Inadequate Risk Assessments: Risk assessments were not conducted consistently before commencement of operations, increasing the likelihood of incidents.
4. Operator Negligence: Three incidents of payloader tip-overs were recorded which were attributed to overloaded buckets.
5. Poor Communication: The mine lacks a structured shift handover process. Currently informal verbal exchanges or your occasional written notes are used during handovers. This has led to crucial information being missed or miscommunicated. A good example of this was when a payloader that was leaking hydraulic oil went unreported during a shift change. This led to the contamination of the work area and stockpile where the payloader was stationed as the incoming shift was not aware of the issue. As a result of the contamination production had to be halted for the day due to safety and health concerns.

5.2 Detailed Incident Analysis

Based on the observations it was clear the mine faced significant safety challenges. The next step was to quantify these challenges to get to the root cause of the incidents. Figure 2 illustrates an overview of incidents across the mine's operational areas. The graph identifies Island View as a hotspot, the area accounted for 44% of all incidents, nearly half of the total incidents at the mine. The Bluff and Wharf side area followed with 16% and 14% of incidents respectively, highlighting Island View as a high-risk operational area. Building on the insights from Figure 2, Figure 3 provides a detailed breakdown of the incident occurrence per operational area. Island View had a total of 22 incidents, significantly surpassing Bluff and Wharf Side, which recorded 8 and 7 incidents, respectively. This data clearly identifies Island View not just as a high-risk operational area but as the central focus of safety concerns within the mine.

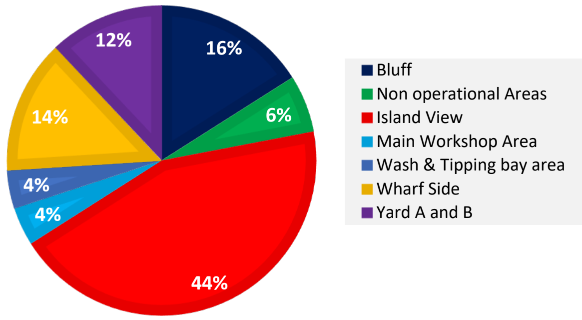

Figure 2. Incident by Operational Area

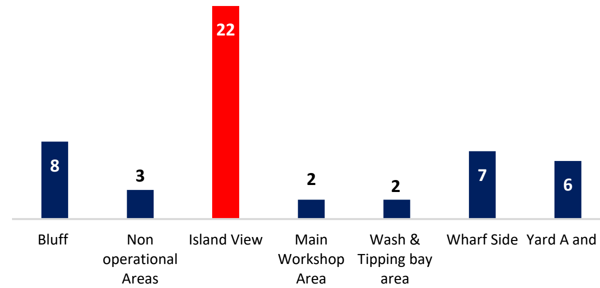

Figure 3. Total Incidents by Operational Area

5.2.1 Assessing the underlying root causes responsible for the high rate of incidents at the mine

Island View was identified as a high-risk operational area, responsible for a significant number of incidents at the mine. This raised critical questions regarding the underlying factors contributing to this trend. Why was Island View a hot spot for incidents at the mine? A fishbone analysis was conducted to systematically explore and identify the root causes of this trend to formulate targeted corrective measures to address the identified safety concerns, refer to Figure 4 for the fishbone diagram.

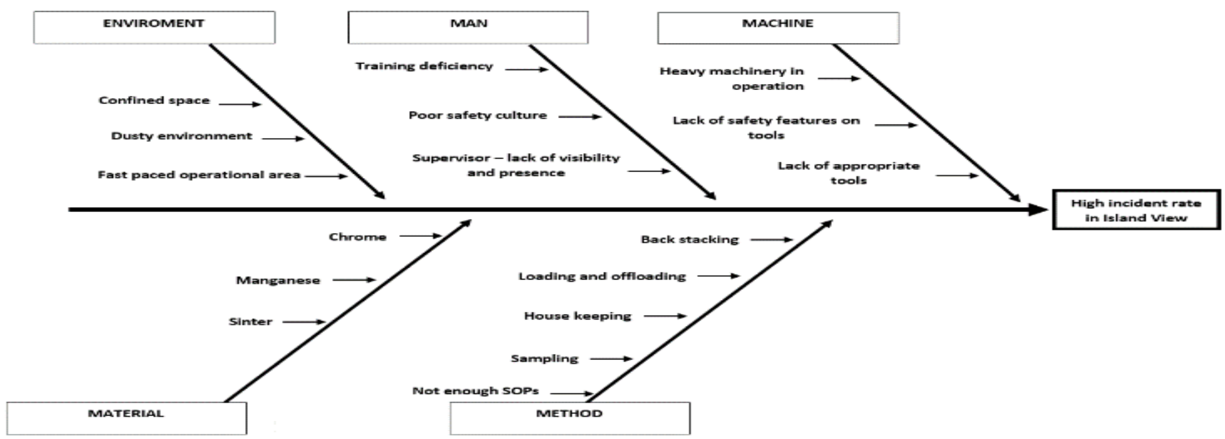

Figure 4. Island View Fishbone Diagram

Factors contributing to the high rate of incidents at Island View:

1. *Environment*: The physical layout and environmental conditions of the area present significant operational challenges, characterized by narrow passages that increase the risk of collisions, protruding steel near the railway line, and poor visibility due to pervasive dust and a lack of ventilation. Furthermore, the area is a hub of simultaneous activities, including the offloading of trucks, samplers collecting samples, back stacking and housekeeping activities, all occurring in a confined space, resulting in a high-risk area.
2. *Man*: Human factors contributed significantly to safety risks at the mine. Key issues included: Inadequate safety training for flagmen, leading to traffic congestion and collisions. There was no mandatory safety induction for general workers, leaving them unaware of area-specific hazards. Insufficient supervisor presence and visibility resulted in a relaxed attitude towards safety protocols. These factors combined to compromise operational safety, increasing the likelihood of incidents.
3. *Machine*: The area is extremely busy, due to the constant presence of heavy equipment such as tipping trucks, payloaders, private cars, and skid steers. There is also the presence of inadequate safety measures such as certain payloaders operating with non-functional reverse cameras and there is poor lighting in stacking areas, reducing visibility. Combined, these factors increase the likelihood of incidents, particularly in low-visibility conditions like nighttime or dusty environments.
4. *Material*: The area stores three hazardous materials - chrome, manganese, and sinter - posing significant safety and environmental risks. The lack of standard operating procedures for handling these materials led to

frequent incidents including equipment tip-overs due to overload and environmental contamination from improper material storage and handling.

5. *Method*: The area lacks comprehensive Standard Operating Procedures (SOPs) for tasks like back-stacking, loading, and sampling, creating an unsafe environment prone to incidents. Key safety gaps include: lack of safety briefings such as toolbox talks and clear emergency response procedures, leading to delayed incident responses and inadequate preventive measures.

The findings of the study revealed a significant safety concern at the mine, as evidenced by the consistent pattern of incidents throughout the year. This corroborates with the observations made during the site visit, the results of the fishbone analysis and the safety records, which collectively revealed a poor safety culture that was characterized by non-compliance with safety regulations. A deeper analysis revealed Island View as a high-risk operational area due to multiple factors such as the constant presence and operation of heavy equipment in a confined space, lack of safety training for employees (e.g., flagmen, general workers), lack of comprehensive Standard Operating Procedures (SOPs) for various tasks and general lack of compliance to safety regulations (e.g., mobile device usage while operating equipment). The identified safety factors compromised the daily operations and hindered organizational performance at the mine, leading to inefficiencies and operational downtime.

5.2.2 Assessing the impact of poor safety on organizational performance

Based on the findings from the observations, fishbone analysis and safety records, it is evident that poor safety operations had an impact on the mine's daily operations. The safety issues identified were a major contributing factor to the high rate of incidents, which resulted in frequent operational disruptions. As a result, the high rate of incidents led to extended periods of operational downtime. Negatively affecting the mine's overall performance and productivity. Figure 5 illustrates the profound impact of these incidents from an operational downtime perspective. December was the most severely impacted month, during which a staggering 85 hours and 46 minutes of production time were Lost due to operational downtime. In November, there were 32 hours and 5 minutes of downtime, followed by October with 21 hours and 20 minutes of downtime, respectively. The operational downtime over these three months constituted the bulk of the overall downtime, underscoring the pressing necessity for improved safety protocols.

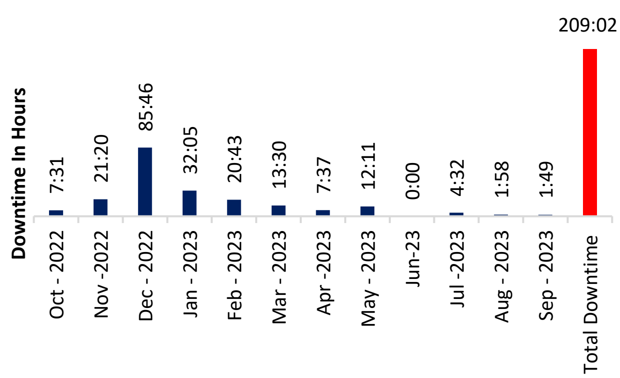

Figure 5. Operational Downtime by Safety Related Incidents

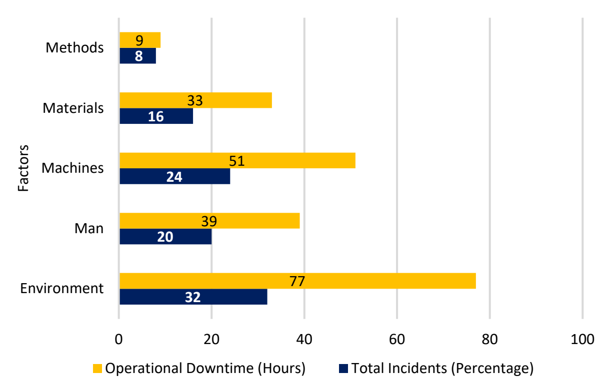

Figure 6. Total Number of Incidents and Operational Downtime by Factor

Over the 12-month period, the mine incurred a total of 209 hours of operational downtime due to safety-related incidents. This significant loss highlights the profound impact of poor safety on operational efficiency and organizational performance. The 209 hours represent lost production time that could have been productively allocated to advancing production and mining operations, further highlighting the significant toll that safety issues took on the mine's organizational performance. This analysis underscores the pressing need for improvements in safety measures to mitigate such substantial losses and enhance the mine's operational success.

Figure 6 provides a quantitative analysis of the major factors that contributed to safety incidents at the mine. Environmental-related incidents accounted for 32% of the total incidents, resulting in 77 hours of operational downtime. Island View was identified as a high-risk area due to environmental conditions, which increased the likelihood of incidents and extended recovery time. Machine-related incidents accounted for 24% of the total incidents, resulting in 51 hours of operational downtime, as the absence of safety features like reverse cameras on payloaders led to more frequent collisions and longer recovery periods. Man-related incidents accounted for 20% of the total incidents, resulting in 39 hours of operational downtime, due to inadequate training and supervision during operational activities. Material-related incidents accounted for 16% of the total incidents, resulting in 33 hours of operational downtime, mainly due to equipment tip-overs and contamination, which required significant cleanup. Method-related incidents, though only 8% of the total, caused 9 hours of downtime, primarily due to delays from insufficient standard operating procedures and emergency planning.

5.2.3 Recommendations

This study assessed the impact of poor safety operations on organizational performance. The findings revealed a poor safety culture at the mine that was characterized by high-risk operational areas, non-compliance with safety regulations and lack of SOPs as some of the key contributing factors to the high rate of incidents at the mine. A deeper analysis illustrated the profound effect that these safety deficiencies had on operational downtime, which in turn had a significant impact on the mine's productivity, presenting an opportunity loss for the mine. The lost hours as a result of operational downtime clearly illustrates the crucial role that safety plays in influencing organizational performance from a productivity perspective. The findings highlighted the need for comprehensive safety measures to address the identified issues and mitigate the risks associated with Island View and the broader operations at the mine. To address the safety issues identified, the recommendations are as follows:

Environmental Factors:

Workplace safety and efficiency are influenced by a combination of environmental and human factors, each of which requires attention to mitigate risks and enhance performance. *Environmental factors* are foundational to creating a safe working environment. One of the most pressing concerns is the layout of the workspace. Overcrowded areas and narrow pathways can limit mobility and lead to accidents, so strategies like traffic management plans are essential. For instance, implementing one-way traffic flows and designated routes for equipment can prevent collisions and bottlenecks. Similarly, poor lighting and excessive dust are hazardous. In dimly lit areas, especially in zones where heavy lifting or stacking occurs, visibility is crucial. Installing extra lighting can reduce accidents, while dust suppression systems, such as sprinklers, can improve air quality and visibility, mitigating long-term health risks. Additionally, physical hazards like protruding steel or other sharp objects present serious injury risks. Simple solutions like safety barriers or protective guards can significantly reduce these dangers.

On the *human behaviour* side, safety training is paramount. Workers often lack the proper understanding of how to handle materials safely, which leads to unnecessary accidents. Therefore, comprehensive safety training, with regular refreshers, should be a priority. These programs need to cover key practices for safe material handling during tasks like loading and unloading. Supervisory oversight is another critical aspect. In many cases, a visible and engaged supervisor fosters a strong safety culture, where workers are reminded of protocols and standards. Safety briefings, such as daily toolbox talks or regular safety audits, can reinforce the importance of adhering to guidelines. Encouraging workers to take ownership of workplace safety by reporting hazards or unsafe behaviors helps to maintain a culture where safety is prioritized.

Method Factors:

In industrial and mining environments, workplace safety and efficiency are heavily influenced by method, machine, and material factors. Addressing each of these areas is essential for minimizing risks and improving operational outcomes. *Method factors* relate to the processes and procedures governing workplace tasks. A significant issue in many environments is the absence of Standard Operating Procedures (SOPs) or the failure to adhere to them. SOPs are crucial for ensuring that every task, from basic operations to complex procedures, is performed safely and efficiently. Organizations should develop comprehensive SOPs that cover all critical tasks and processes. To ensure effectiveness, SOPs should be tailored to the specific high-risk operations identified in the study. For example, a loading SOP at Island View should define proper back-stacking procedures, load limits for payloaders, mandatory use of reverse cameras, and a pre-operation checklist. Similarly, an SOP for handling hazardous materials should include step-by-step instructions on safe offloading, PPE requirements, spill management procedures, and designated storage zones. All SOPs should be supported by visual aids and be integrated into daily toolbox talks to reinforce awareness. Regular audits should assess compliance and effectiveness, ensuring SOPs evolve with operational needs. Furthermore, to stay ahead of potential hazards, regular risk assessments should be performed across all operational areas. These assessments help identify vulnerabilities, allowing the organization to implement preventive measures before accidents occur. Every workplace should not only have an emergency response plan but also ensure that all employees are adequately trained in emergency procedures, so they know exactly how to act in the event of an accident or dangerous situation.

Machine factors play a pivotal role in maintaining safety. One of the key issues is ensuring that equipment is equipped with up-to-date safety features. For instance, payloaders, excavators, and other heavy machinery should be fitted with functional reverse cameras to enhance rear visibility and prevent collisions. In addition to reverse cameras, in-cab camera systems can further boost safety by allowing supervisors to monitor operator behaviour. This encourages adherence to best practices and helps identify potential issues before they result in accidents, ensuring that operators remain focused and comply with safety standards.

Material factors center around the handling and storage of hazardous materials. These substances, if not managed properly, can lead to severe accidents. To mitigate this, standardized procedures must be established for the safe handling, storage, and disposal of hazardous materials. This includes providing employees with proper training on these procedures to ensure that they are aware of the risks and know how to handle materials safely. Consistent compliance with these protocols is critical to preventing workplace accidents, particularly in environments where hazardous materials are frequently used or stored. Table 1 below summarizes the key issues identified during the study alongside the corresponding recommended actions. This is intended to provide a clear and actionable reference for mine management and safety practitioners.

Table 1. Summary of Key Issues and Recommended Actions

Identified Issue	Root Cause	Recommended Action
Use of mobile phones while operating equipment	Lack of enforcement of safety rules and inadequate supervision	Develop and enforce a Mobile Equipment Operation SOP; implement random safety audits
Frequent payloader tip-overs due to overloading	Absence of clear SOPs; insufficient operator training	Create SOPs for loading practices; provide operator refresher training
Inconsistent or missing toolbox talks	No formal structure or scheduling of safety briefings	Introduce a Toolbox Talk SOP; mandate daily briefings using structured templates
Island View high incident rate	Congested layout, poor lighting, excessive dust, multiple tasks	Redesign traffic flow; install lighting; implement dust suppression and signage
Poor shift handovers	Informal handover process with missing critical info	Implement a Shift Handover SOP with standardized checklists and logbooks
Improper handling of hazardous materials	Lack of training and SOPs for high-risk materials	Develop and implement SOPs for handling/storing chrome, manganese, and sinter; train staff
Operator negligence and safety non-compliance	Weak safety culture and lack of accountability	Promote a safety-first culture through leadership, incentives, and disciplinary actions

6. Conclusion

The primary aim of the study was to assess the safety operations at XYZ Mine with the intention to offer solutions aimed at reducing safety incidents thereby enhancing organizational performance at the mine. The study successfully achieved its objectives through a systematic approach that involved root cause analysis, impact assessment, and the development of strategic corrective measures. The first objective of the study sought to determine the root cause of safety incidents. The fishbone analysis systematically illustrated the various factors that contributed to the high rate of safety incidents by looking at the human, methodological, material, environmental, and equipment-related aspects within the high-risk operational area of the mine.

The second objective sought to evaluate the impact of the safety incidences on organizational performance. A detailed analysis revealed that the identified root causes created an operational environment that was prone to frequent safety incidents. These recurring incidents negatively affected the mine's overall organizational performance, from a productivity and safety perspective. The third objective developed tailored solutions to reduce safety incidents and improve organizational performance. Some of the solutions included enhancing supervisor visibility, implementing on-going operator refresher training, and fostering a safety culture through continuous training and risk assessments. These solutions were designed to directly address the root causes identified and provide a sustainable framework for enhancing safety performance.

In conclusion, by implementing the corrective measures suggested, XYZ mine can significantly reduce operational downtime, improve productivity, and therefore enhance its overall organizational performance and long-term sustainability. Future research should consider a broader comparison across diverse mines (gold, coal, platinum) in South Africa and internationally to identify common challenges and unique factors and develop generalized solutions applicable industry-wide.

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