DEVELOPING A FRAMEWORK FOR OCCUPATIONAL SAFETY AT A GLOBAL MINING COMPANY BASED IN SOUTH AFRICA

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Abstract

Mining is a significant contributor to many countries' economies but is also recognized as one of the most hazardous occupations. Incident investigations play a pivotal role in identifying vulnerabilities within occupational incidents and accidents. Traditionally, these investigations have been reactive, with a focus on understanding incidents post-occurrence, often attributing human error as the primary cause. How- ever, there has been limited exploration into the role of health and associated risks in these incidents. This study suggests a paradigm shift towards proactive measures and preventive approaches in the mining industry. The research presents a case study of a global mining company based in South Africa, which has effectively integrated proactive strategies in addressing the nexus between employee health and workplace safety. The study highlights that by adopting proactive interventions, such as consistent health monitoring, refining procedures, and a comprehensive understanding of incident-related costs, a safer and more productive working environment can be cultivated. Key strategies identified include diverse professional perspectives fostering an effective people-focused incident investigation methodology, health risk identification, fatigue management, and the incorporation of comprehensive cost analyses. These proactive measures have shown to significantly improve safety and productivity. Additionally, considering the social development and community im- pacts ensures that the safety improvements benefit not just the company but also the broader community. This research champions the view that prioritizing employee well-being reduces workplace incidents and their associated costs—necessitating a shift from a cost-centric to a people-centric approach. When implemented effectively, this holistic consideration of safety and well-being has the potential to transform safety measures, decrease incidences, and enhance a global mining company based in South Africa's financial performance.

Keywords

Health Risk Factors; Human Error; Incidents Investigation;Unsafe Acts

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Introduction

The mining industry is marked by significant technological advancements and heightened safety measures, yet it remains marred by an inordinately high number of occupational incidents and fatalities [1]. This enduring issue calls attention to the necessity of greater understanding and enhanced preventive strategies. Historically, mining incident investigations have zoomed in on unsafe acts and conditions as predominant accident precipitators [2]. Although crucial, such a focus does not account for the health and well-being of employees—a facet now acknowledged as a potential determinant in behaviour and decision-making, influencing the manifestation of unsafe acts [3].

A glaring gap within the mining sector lies in the scant regard for employee health and wellness within occupational incident investigations. This lack, alongside the flaws it introduces in safety and financial terms for mining entities, poses substantial operational, legal, and reputational costs. The cornerstone of this research is to forge a risk management framework for investigating occupational incidents at a global mining company based in South Africa, one that cogently incorporates health and wellness determinants. This framework is envisioned to propel an incident investigation paradigm, adept at identifying and negating health-associated risks, thereby forestalling future incidents and bolstering safety within the mining milieu. The study seeks to address the following research questions: In what ways do health-related risks among employees influence safety incidents at a global mining company based in South Africa? How could an incident investigation methodology be designed to encompass health-related factors? To what extent do occupational incidents bear financial implications on a global mining company based in South Africa ’s business performance?

Research Settings

A global mining company based in South Africa, the fulcrum of this study, operates within the explosive provisions and blasting domain for the global mining sector, harbouring a broad spectrum of operations and incident chronicles. This offers an in- valuable chance to dissect the myriad health dilemmas that miners grapple with and assess their profound effects on safety outcomes.

Despite ardent pursuit of zero fatalities and injuries by various stakeholders like the Department of Mineral Resources and Energy (DMRE) and the Minerals Council of South Africa, persistent incidents in platinum and gold sectors highlights the urgency of proactive risk handling [4]. Current models, such as health self-assessment templates used in a global mining company based in South Africa, demonstrate a stark omission of integral health statistics, thereby sustaining the lineage of health-induced incidents. This study thus positions itself at the nexus of occupational safety and employee health in the mining industry, seeking to engender a seismic shift in incident mitigation strategies.

Literature Review

Part 1: Impact of incidents and accidents

The Centre for Chemical Process Safety categorizes incidents into accidents, near- misses, and operational interruptions, defining the latter as scenarios where production rates or product quality are significantly compromised. The immediate and effective addressing of incidents involving property damage, environmental harm, or human casualties is crucial for recovery and prevention of further damage.

Occupational injuries not only impose financial burdens but also affect the physical and emotional well-being of individuals and their families, leading to reduced productivity and employee morale [5]. Furthermore, the International Labour Organisation’s estimates highlight a pressing need for enhanced measures in health and safety, evidenced by the substantial annual rates of work-related non-fatal injuries and fatalities [5]. This highlights the critical need for continuous improvement in workplace

safety protocols and preventive strategies.

Part 2: Cost of Incidents Driving the Need for Reduction or Total Elimination

Ensuring safety in South African mines is paramount, yet incidents persist, causing not only tragic injuries and fatalities but also imposing substantial financial burdens on mining operations [6]. Incident costs encompass both direct costs (e.g., medical expenses, equipment repair) and often larger, hidden indirect costs (e.g., lost production, increased insurance premiums, reputational damage) [7].

Indirect costs, likened to the submerged portion of an iceberg, often exceed direct costs and can significantly erode profit margins [8]. This discrepancy highlights the importance of reducing or eliminating these incidents. For example, a R2 mil- lion work stoppage incurs not only direct costs but also necessitates an additional R10 million in sales to recover the associated lost profits, assuming a 20% profit margin. This figure illustrates the leveraged effect of incident costs under challenging economic conditions and emphasizes the urgency of effective preventive measures [9].

A comprehensive understanding of these costs is essential. Direct costs represent the immediate financial aftermath of incidents, including medical expenses, equipment repair or replacement, and potential regulatory fines. Although substantial, these costs constitute only a fraction of the total financial impact [10].

On the other hand, indirect costs, though less visible, can be far more significant. They comprise lost productivity due to operational disruptions, increased insurance premiums resulting from a heightened risk profile, and reputational damage that can deter prospective clients and investors [11]. These costs also cover decreased employee morale, which can lead to lowered productivity and increased staff turnover, further exacerbating financial losses.

Part 3: Role of Human Error

A Human error in mining, defined as actions that deviate from established safe practices leading to undesirable outcomes, is a major contributor to accidents and inefficiencies [12]. These errors arise from various factors, including the prioritization of production over safety, insufficient knowledge of equipment and hazards, and systemic deficiencies, ultimately leading to severe consequences such as fatal accidents, financial losses, environmental damage, and reputational harm [13].

The interconnected relationship between human factors and human errors plays a crucial role. According to Reason [14], errors are planned actions that fail to achieve their intended outcomes. Rasmussen [15] describes these errors as mismatches between individuals and their tasks or tools, which can arise from poor design or system inconsistencies. Recognizing and addressing these can significantly improve safety and operational effectiveness.

Key Areas of Human Errors in Mining:

Safety and Ergonomic Risks:

Inadequate safety procedures, insufficient training, and ergonomic challenges due to poorly designed equipment create conditions prone to errors. Actively addressing these areas can significantly reduce the incidence of human errors [12, 16–18].

Injuries and Accidents:

Human errors frequently result in a range of accidents and injuries, from minor to fatal. These incidents provide crucial lessons that drive the improvement of safety protocols and enhance organizational learning [13, 19].

Mining Equipment:

Complex equipment, design flaws, and inadequate operator training are significant sources of errors. Integrating advanced equipment with automation and enhanced safety features can help mitigate these risks, ensuring better safety and efficiency [20– 22].

Automation and New Technologies:

Implementing technologies such as autonomous vehicles, wearable safety devices, and predictive safety analytics can minimize human exposure to hazards and proactively identify risks, thus reducing the potential for human errors [23, 24].

Mineral Processing Plants:

The complexity of operations and the potential for miscommunication in mineral processing plants are prevalent sources of human errors. Enhancing understanding of these processes and improving communication are essential strategies for reducing errors in this sector [25, 26].

By comprehensively addressing these facets, the mining industry can significantly reduce human errors, enhancing both safety and productivity. This effort requires a committed approach to revising safety protocols, integrating advanced technologies, and fostering a culture that prioritizes safety over operational output.

Part 4: The Human Factors Analysis and Classification System (HFACS)

The Human Factors Analysis and Classification System (HFACS) stands as a holistic approach for scrutinizing human and organizational elements that play a part in accidents. It extends Reason's [14] Swiss Cheese Model by offering a detailed map to pinpoint human factors within a system's framework. HFACS delineates accident causes across four hierarchical levels: organizational influences, unsafe supervision, preconditions for unsafe acts, and unsafe acts of operators, fostering a structured investigation into the diverse dimensions of human errors [27].

Organizational Influences:

This layer explores the critical decisions made at the management level concerning the allocation of resources towards safety measures, equipment, and training. It high- lights that effective management and allocation of resources are pivotal in minimizing the occurrence of unsafe acts [27–30].

Unsafe Supervision:

Attention is directed to the significant role of direct supervision in championing safety. Factors such as subpar supervision, insufficiently planned supervisory strategies, and the oversight of known hazards can lead to unsafe conditions and, subsequently, accidents [31, 32].

Preconditions for Unsafe Acts:

This tier addresses several factors, including individual conditions (for example, fatigue, illness), environmental challenges (such as harsh working conditions, equipment failure), and specific operator circumstances that may lay the groundwork for unsafe actions [33, 34].

Unsafe Acts of Operators:

At this juncture, focus is placed on errors (decision, skill-based, and perceptual) and violations (routine and exceptional) perpetrated by operators, culminating in accidents [27, 35].

Gap Identified in HFACS:

Although HFACS incorporates the "condition of operators" as a precursor to unsafe acts, it falls short in thoroughly examining the root causes of these conditions. This research strives to bridge this gap by

delving into the intersection between health and wellness factors and unsafe behaviours, aiming to enrich the HFACS framework with a more nuanced appreciation of the contributors to human error specifically within the mining sector [27].

By amplifying the scope of HFACS to encompass health and wellness considerations, we can enhance its utility in not only diagnosing but also pre-empting human errors in mining, thus bolstering both safety and operational efficacy.

Part 5: Preconditions for Unsafe Acts and the Role of Health and Wellness

Understanding the root causes of accidents is a central objective in enhancing safety. The Human Factors Analysis and Classification System (HFACS), which builds upon Reason's Swiss Cheese Model, provides a layered framework for analysing incidents [36]. However, the current literature suggests that the impact of health and wellness on accident causation might be inadequately emphasized within the HFACS framework.

The Swiss Cheese Model and HFACS:

The seminal Swiss Cheese Model posits that accidents can happen when systemic weaknesses, represented as holes in slices of cheese, line up. These gaps represent active and latent failures, with active failures being immediate and latent ones embedded in the system over time [37]. HFACS extends this model by classifying the nature of these weaknesses and providing a nuanced look into the causation factors, such as organizational flaws or unsafe supervision, which may precipitate an operator's unsafe acts [38].

Gap in the Model – Health and Wellness:

Within the context of HFACS's "condition of operators," there is an acknowledgment of factors like fatigue, but a systematic exploration of the full scope of health and wellness appears lacking [35]. This research supports the notion of formally integrating health and wellness into HFACS to encapsulate a more complete impression of operator conditions. The role of health and wellness as contributing factors can be outlined in several key areas including:

Sleep:

There's robust evidence linking inadequate sleep with diminished cognitive performance and error-pronation. Such impairment can threaten the integrity of operations, particularly in high-risk industries like mining (Wong et al., 2020).

Stress:

Elevated stress levels are notorious for compromising decision-making abilities and promoting unsafe behaviours. The mining industry, with its inherent stressors, cannot afford to overlook this aspect [39].

Fatigue:

Not limited to sleep deprivation, fatigue encompasses broader physical and mental exhaustion. Recognizing fatigue-related conditions as precursors to unsafe acts can inform better shift scheduling and workload management.

Chronic Illnesses:

The role of chronic health conditions in predisposing operators to incidents requires more attention. A deeper understanding can lead to tailored workplace adjustments that mitigate these risks [33].

Presenteeism:

The tendency to work while sick, known as presenteeism, has implications beyond individual productivity, potentially increasing the propensity for making errors [40, 41].

Proposed Integration into HFACS:

The research posits that by including health and wellness as an explicit category within the preconditions for unsafe acts, HFACS could offer a more thorough view of the underlying issues, paving the way for better identification of intervention points. Integrating this dimension into the HFACS framework could complement existing safety measures by incorporating: Health and wellness screenings; Fatigue management pro- grams; Stress reduction strategies; and sleep awareness and assistance initiatives.

Part 6: Proposed Incident Investigation Framework

Employees grapple with the decision to disclose medical conditions within hazardous work environments like mining, weighing the risk of harm against potential repercussions such as retrenchment or medical boarding [42]. This dilemma extends to chronic conditions, underpinning the complex interplay between personal health and workplace safety.

The literature highlights the influence of health and wellness on operational safety yet reveals a gap in integrating these aspects into occupational incident analysis. De- spite the adoption of frameworks like the Human Factors Analysis and Classification System (HFACS) which consider health and wellness, the depth of their investigation into incidents remains unclear. The proposed incorporation of health and wellness factors depicted in Figure 1, highlights this research deficit, especially in the context of contemporary lifestyle and stress challenges.

Figure 1 - is located at the end of the article

Risk management approaches are vital for enhancing workplace safety across all sectors, focusing on the identification and mitigation of potential hazards [43]. In the mining sector, thorough accident investigations shed light on systemic failures and the significant role of human factors, as historical analyses and models such as Heinrich's Domino Theory have illustrated [44, 45]. However, despite recognizing stress and fatigue as contributors to unsafe acts, existing research seldom examines how individual health and wellness issues precipitate occupational accidents.

This review reveals an imperative to explore the health and psychological conditions that predispose workers to accidents, a crucial yet overlooked element in incident investigations. Barkhordari et al. [45] pinpoint this oversight, prompting a deeper exploration of the interrelations between health, wellness, and accident causation in this study.

Methodology

This study adopts a mixed methods methodology to thoroughly investigate the interplay between health, wellness, and their impact on workplace accidents. This approach allows for an in-depth exploration of both quantitative and qualitative data, providing a comprehensive understanding of the factors contributing to occupational incidents [46].

Participant Selection

The study targeted the occupational medical team and senior management of a global mining company based in South Africa, employing a homogeneous purposive sampling strategy. Participants were selected based on the criterion of having a minimum of three years of experience in their respective roles [47]. This ensured that all participants possessed a substantial understanding and

direct experience of the occupational safety practices being scrutinized.

Data Collection Methods

Data were gathered through surveys and semi-structured interviews, a method chosen for its balance between structured and spontaneous data collection, allowing for an in-depth exploration of individual experiences, opinions, and perspectives [48]. Interviews were meticulously prepared to include open-ended questions fostering rich, detailed responses. The number of interviews and their durations, although not specified here, were determined by the saturation point of information, a criterion ensuring comprehensive coverage of the study's thematic concerns. Likewise, surveys were issued to employees using the simple random sampling method was by sending out invitations to the eligible population of 159 employees.

Qualitative Analysis

The first phase of the research involves a qualitative analysis through semi-structured interviews with employees who have experienced workplace accidents and opted to dis- close their health conditions, as well as safety officers and health professionals within the mining sector. The aim is to explore personal experiences, perceptions of health disclosure, and the impacts of workplace culture on safety and health management. Interviews were recorded, transcribed, and analysed using thematic analysis to identify common themes and insights related to health disclosure and safety outcomes [49].

Quantitative Analysis

Following the qualitative analysis, a quantitative analysis of incident reports and health records from selected mining companies over the past five years was undertaken. Statistical methods were employed to identify patterns and correlations between reported health conditions and the incidence of accidents [50, 51]. This dataset was subjected to regression analysis to determine the predictive value of specific health conditions on the likelihood of workplace incidents. Data was anonymized to ensure confidentiality and analysed using SPSS (Version 26).

Mixed Methods Integration

The findings from both quantitative and qualitative phases were integrated in the final analysis to draw comprehensive conclusions. This integration was achieved through a comparative analysis of the statistical outcomes and thematic insights, enabling a nuanced understanding of how health and wellness factors contribute to work- place accidents [52]. This approach facilitates a multi-dimensional exploration of the problem, addressing both the statistical correlations and the human experiences behind the data.

Ethical Consideration and Trustworthiness

This study received approval from the University Ethics Committee. All participants provided informed consent, and measures were taken to ensure confidentiality and anonymity of personal and company information. Ensuring the trustworthiness of qualitative research involves demonstrating credibility, dependability, conformability, and transferability [53]. This study took several steps to establish these criteria: Credibility was achieved through the use of detailed descriptions of participant perspectives and triangulation of data sources; Dependability was addressed by providing a clear account of the research process and the decision-making trail; Conformability was ensured through diligent efforts to minimize the researchers' biases and assumptions in data interpretation and analysis; Transferability was facilitated by a thorough description of the research context and methodologies, allowing for the evaluation of applicability in other contexts.

The methodology adopted for this study facilitated a comprehensive and insightful exploration into mitigating strategies for occupational occurrences at a global mining company based in South Africa. Through careful design and execution of the research approached, including rigorous methodological choices and adherence to principles of trustworthiness, this study contributes valuable perspectives to the domain of occupational health and safety research.

Findings of the Study

The analysis of data obtained through interviews and investigations into the practices at a global mining company based in South Africa reveals significant insights into the company's handling of occupational safety and health-associated risks. The findings emphasize the critical nature of integrating health considerations into safety incident management to enhance productivity and establish a healthier work environment.

Qualitative Findings

Proactive Health Measures and Impact on Safety Incidents

A global mining company based in South Africa's approach to integrating proactive health measures emerges as a substantial contributory factor towards mitigating safety incidents. Regular health monitoring and the refinement of procedures based on health data show promising potential in improving workplace safety [42]. This strategy illustrates the importance of a comprehensive understanding of incident-related costs, not just from a financial perspective but also considering productivity and social impact dimensions. The company's inclination towards a comprehensive strategy indicates an acknowledgment of the complex interactions between employee health and workplace incidents [13].

Adoption of a People-focused Incident Investigation Methodology

A significant revelation from the study involves the necessity for a people-focused incident investigation methodology. Such an approach prioritizes employee health and wellness and recognizes the intrinsic link between well-being and productivity levels [54]. The findings suggest that addressing health risks proactively, managing fatigue rigorously, and analysing the broader costs of occupational incidents can foster a safer and more productive work environment. This methodology advocates for a deeper in- sight into the costs associated with occupational incidents, urging a shift from a purely financial assessment to a more holistic one encompassing employee well-being and social development impacts [55].

Table 1 - is located at the end of the article

Influence of Occupational Incidents on Business Performance

The research highlights the considerable impact occupational incidents have on a global mining company based in South Africa's business performance. A paradigm shift towards prioritizing worker health and wellness is identified as a potential pathway to reducing occupational incidents and their financial implications [7]. The findings suggest that medical fitness, aligned with job requirements, alongside effective fatigue management and a robust cost tracking system, could drastically reduce occupational incidents [56].

Quantitative Findings

The analysis of survey data provided compelling insights into the perceptions of health and wellness initiatives in the workplace, particularly within the mining industry. A significant majority of respondents affirmed the critical role of health and wellness programs in enhancing both safety and

productivity [28]. Furthermore, there's a recognised need for these initiatives to adequately address chronic conditions in the occupational setting.

Table 2 - is located at the end of the article

Despite broad consensus on the value of health and wellness initiatives, areas requiring enhancement were identified. Specifically, the need for improved comprehension among line managers regarding their subordinates' health conditions was highlighted, suggesting a gap in current managerial training or communication practices [57].

This study also explores the integrative approach to incident investigations, incorporating elements of health, wellness, and cost analysis [8]. Such integration offers a more holistic understanding of the factors influencing safety and productivity, potentially guiding the development of more effective workplace strategies.

Moreover, the investigation into current practices around medical surveillance and health risk assessments unveiled in this study [37] highlights the value of assessing and refining these strategies. This approach is pivotal in not only elevating employee well-being but also in aligning safety measures with the industry's evolving needs.

Figure 2 - is located at the end of the article

Figure 2 reveals that the independent variable of health and wellness in the work- place does not have a significant β coefficient of -0.013 and hence no relationship exists between this construct and human errors. Furthermore, the independent variables of health and wellness in the workplace have significant β coefficients of 0.573 and it can be concluded that there is a relationship between health and wellness and occupational incidents in the workplace. Finally, the independent variable of health and wellness in the workplace has significant β coefficients of 0.572 and it can be concluded that a relationship exists between health and wellness and occupational health risk assessments in the workplace.

Importantly, the survey results advocate for a comprehensive, people-cantered approach in incident investigations. This methodology promotes prioritising employee health and wellness, alongside evaluating productivity impacts, identifying risks, managing fatigue, and conducting thorough cost analyses of occupational incidents. Such an inclusive approach, emphasizing broader development aspects including social and community impacts, offers a pathway to more effective and encompassing occupational health and safety strategies.

Case Study Insights

The quantitative findings highlight the unanimous recognition of health and wellness initiatives' importance in the workplace and their direct influence on safety and productivity. Additionally, these insights stress the necessity of integrating health, wellness, and cost considerations into incident investigations and safety management practices [8]. As the case study reveals areas for improvement and provides a basis for refining existing strategies, it contributes significantly to advancing workplace safety and employee well-being in the mining sector.

Therefore, a global mining company based in South Africa serves as an illustrative case study on effectively addressing the interplay between employee health and work- place safety, highlighting strategies that minimize incidents and promote a healthier, more efficient work environment. The adoption of an inclusive perspective on the costs of incidents, encompassing both direct financial impacts and broader social implications, emerges as a critical factor in fostering a safe and productive workplace [40].

Discussion of Findings

Employee Health and Safety Incidents at a global mining company based in South Africa

In high-risk environments such as mining, the correlation between employee health and safety incidents is particularly salient. A global mining company based in South Africa acknowledges the critical nature of this relationship and is thus committed to proactively managing health-associated risks as a means of reducing safety incidents. Conditions such as chronic illnesses, stress, and fatigue have the potential to diminish concentration and physical performance, leading to an elevated risk of accidents.

A global mining company based in South Africa contends with a variety of accident types, including motor vehicle accidents, slips, trips, falls, and machinery-related incidents [13]. These hazards highlight the imperative for stringent safety protocols and effective health management strategies.

To tackle these challenges, a global mining company based in South Africa is advised to implement a comprehensive medical surveillance program. Such a program would be designed to continuously monitor employee health, pinpoint potential hazards, and employ regular health assessments, fatigue management strategies, and proactive risk identification mechanisms [42]. The integration of employee health data into risk assessments and productivity analytics can reinforce safety measures and shape targeted intervention strategies.

By proactively managing health-associated risks, a global mining company based in South Africa positions itself to cultivate a safer working environment, boost productivity, and mitigate the economic repercussions arising from occupational incidents.

Incident Investigation Methodology Incorporating Health and Wellness

A thorough incident investigation methodology that encapsulates health and wellness is indispensable for ensuring occupational safety and health, especially within high-risk industries such as mining. The goal of such a methodology is to detect and temper risks before they culminate in workplace incidents.

Pivotal elements of this integrated methodology include pre-employment and continuous fitness-for-duty evaluations, the integration of health considerations into job specifications and training programs, the utilization of data procured from medical surveillance initiatives, the enactment of wellness programs, and the meticulous tracking of medical surveillance outcomes [55].

Moreover, managing workplace fatigue through regular breaks and wellness initiatives, along with appropriate training, is paramount. Leveraging proactive health risk identification tools presents a strategic means of anticipating and mitigating nascent risks.

The final but crucial aspect involves documenting both the direct and indirect costs associated with occupational incidents, which is vital for grasping their overarching fiscal impact and for steering efficacious safety strategies.

Financial Impact of Occupational Incidents on a global mining company based in South Africa

Occupational incidents wield a substantial influence on business performance, with the mining industry being particularly susceptible. Direct costs manifest as medical treatment and investigative expenses, while indirect costs cover a spectrum that includes diminished productivity, reputational harm, and inflated insurance premiums.

The present study accentuates the interplay between health, wellness, and productivity. It reveals how employee stress [39], fatigue [57, 58], or chronic health conditions [33] can compromise both productivity and safety.

For a global mining company based in South Africa to curtail occupational incidents and their associated financial burden effectively, it should develop job specifications that are cognizant of physical wellness. Additionally, measuring the impact of health on productivity, consistent tracking of medical surveillance data, the implementation of fatigue management practices, investment in proactive health risk identification tools, and detailed tracking of both direct and indirect costs of incidents are all recommended steps.

By placing employee health and wellness at the forefront of its agenda, a global mining company based in South Africa is poised not just to engender a more secure work environment and enhance productivity, but also to bolster its financial standing. This comprehensive and holistic approach harmonizes the company's economic objectives with the establishment of a workplace that is both safe and accommodating for its workforce.

Conclusion

This research has expanded the scope of preconditions for unsafe acts within the heavy industry of mining to encompass health and wellness, suggesting an evolution of the Human Factors Analysis and Classification System (HFACS) as a refined instrument for analysing and preventing accidents. This proposed enlargement of the HFACS frame- work has the potential not only to bolster worker safety but also to exert a positive and enduring influence on operational productivity and success.

The methodology implemented in this study has enabled a meticulous and enlightening examination of methods to mitigate occupational occurrences at a global mining company based in South Africa. Through a well-considered research approach, marked by stringent methodological choices and a steadfast commitment to the principles of trustworthiness, this inquiry contributes essential insights to the field of occupational health and safety.

The results shed light on the crucial significance of adopting a comprehensive strategy towards occupational health and safety in the mining sector. By giving precedence to health-cantered initiatives and utilizing a people-centric approach to incident investigation, a global mining company based in South Africa stands to significantly curtail occupational incidents and, in so doing, enhance its business efficacy. The study high- lights an imminent need for a paradigm shifts towards a corporate culture that regards employee well-being as foundational to the fulfilment of both safety and productivity objectives.

The economic repercussions of incidents in the mining industry extend substantially beyond the immediate, observable expenses. To effectively fortify risk management and guarantee the enduring viability of mining operations, it is imperative to acknowledge and systematically address both the overt direct costs and the more covert indirect costs.

Ultimately, confronting human error within the mining context demands a comprehensive strategy that encompasses safety protocols, equipment design, training, techno- logical innovations, and efficacious communication. By unravelling the diverse elements that contribute to human error, the mining industry can forge a working environment that is not only safer but also markedly more efficient.

Illustrations

Table 1. Summary of Themes on Health and Safety Interaction

Theme	Description
Proactive Health Intervention	Regular health monitoring and procedure refinement significantly contribute to a decrease in safety incidents.
People-focused Incident Investigation	Emphasizing employee health and wellness in incident investigations enhances productivity and safety.
Holistic Approach to Cost Analysis	Moving beyond financial costs to include the broader impacts on employee health and community welfare.

Table 2. Overview of Construct Results

Variable	N	Mean Standard deviation	Skewness	Kurtosis	% Variance Explained
Health and wellness in the workplace	124	3.572 0.823	-0.570	0.154	43.008
Human errors	124	4.019 0.683	-1.419	3.273	46.835
Occupational incidents	124	3.242 0.894	-0.483	0.074	54.325
Occupational health risk assessments	124	3.380 0.775	-0.504	0.647	48.377

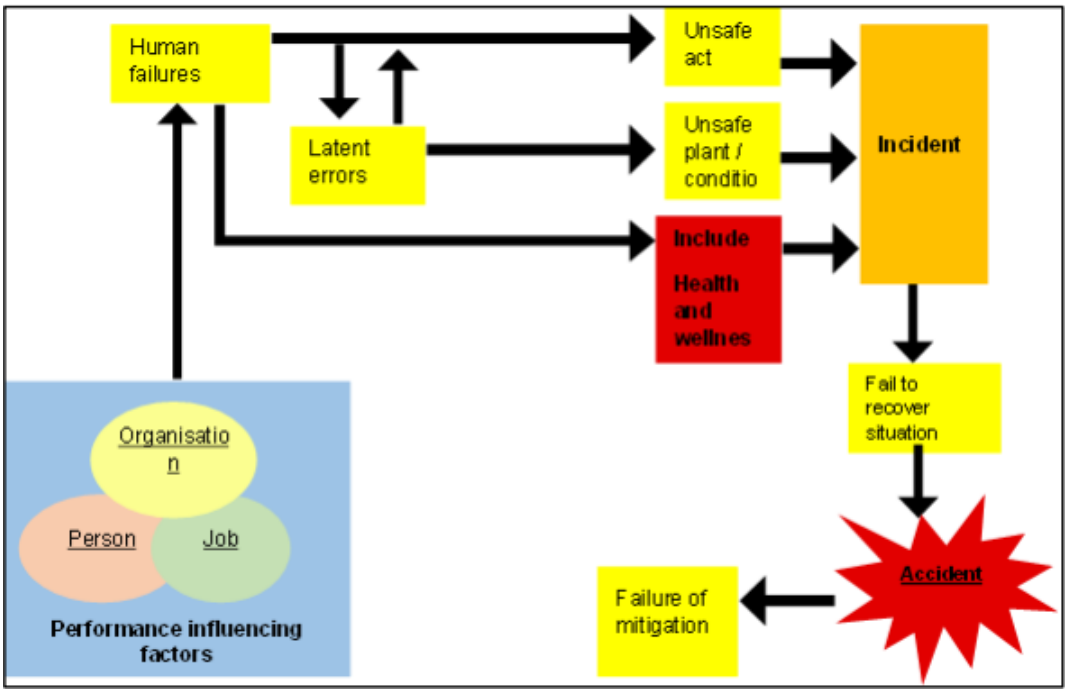

Figure 1. Proposed incident investigation framework

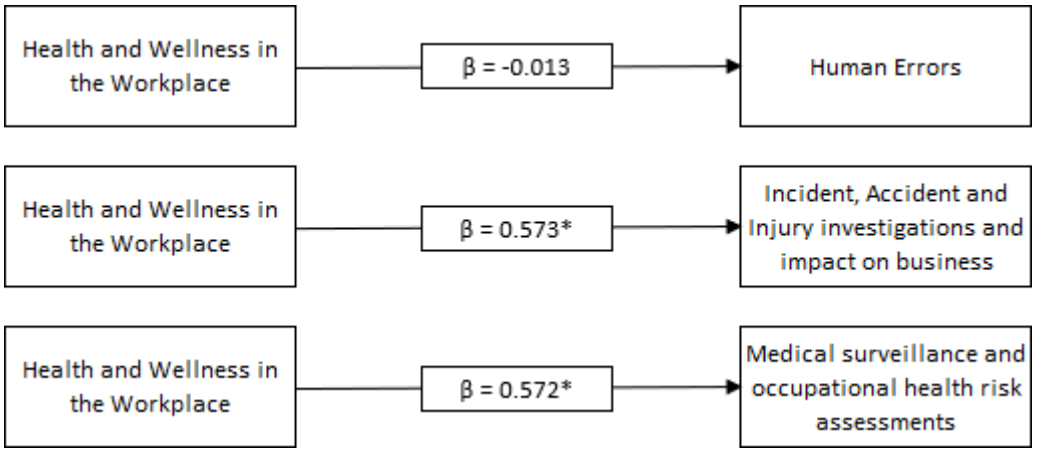

Figure 2. Final theoretical framework results

References

[1] AMOAKO, R., BUABA, J. & BRICKEY, A., 2021. Identifying Risk Factors from MSHA Accidents and Injury Data Using Logistic Regression. *Mining, Metallurgy & Exploration: An Official International Peer-reviewed Journal of the Society*, 38(1), pp. 529. https://doi.org/10.1007/s42461-020-00347-x

[2] BONSU, J., VAN DYK, W., FRANZIDIS, J.P., PETERSEN, F. & ISAFIADE, A., 2017. A systemic study of mining accident causality: an analysis of 91 mining accidents from a platinum mine in South Africa. *Journal of the Southern African Institute of Mining and Metallurgy*, 117(1), pp. 59-66. http://dx.doi.org/10.17159/2411-9717/2017/v117n1a9

[3] DODOO, J. E. & SAMARRAIE, H. A., 2021. A systematic review of factors leading to occupational. *Journal of Public Health: From Theory to Practice*., 31, pp. 99–113. https://doi.org/10.1007/s10389-020-01427-4

[4] DMRE. *Mining industry commits reducing fatalities and injuries*. 2021. Available from: https://www.sanews.gov.za/south-africa/dmre-mining-industry-commits-reducing-fatalities-and-injuries.

[5] SENAPATI, A., BHATTACHERJEE, A. & CHATTERJEE, S., 2022. Causal relationship of some personal and impersonal variates to occupational injuries at continuous miner worksites in underground. *Safety Science*, 146, pp. 105562. https://doi.org/10.1016/j.ssci.2021.105562

[6] CRUMP, B., 2023. Quantifying Financial Impact of Quality Improvement Programmes: Lessons and Limitations. In *Shaping High Quality, Affordable and Equitable Healthcare: Meaningful Innovation and System Transformation* (pp. 207-231). Cham: Springer International Publishing.

[7] OKOLIEUWA, C., CHRISTOPHER, I. & IKWUNNE, T., 2023. Impact and Significance of Occupational Health and Safety Policies on Workers Performance in Workplace: A Case Study of NNPC, Enugu Depot. *American Journal of Applied Sciences and Engineering*, 4(1), pp.24–37. https://doi.org/10.5281/zenodo.8001159

[8] PREIS, E. & WEBBER-YOUNGMAN, R.C.W. 2021. Identification of cost factors relating to mining incidents. *Journal of the Southern African Institute of Mining and Metallurgy*, 121(1), pp. 39-46. http://dx.doi.org/10.17159/2411-9717/16/484/2021

[9] DOEHRING, M.C., CURTICE, H., HUNTER, B.R., OAXACA, D.M., SATORIUS, A., REED, K., BECKMAN, A., VAUGHN, T. & PALMER, M., 2023. Exploring verbal and physical workplace violence in a large, urban emergency department. *The American Journal of Emergency Medicine*, 67, pp.1-4. https://doi.org/10.1016/j.ajem.2023.01.036

[10] WITT, M.A., LEWIN, A.Y., LI, P.P. & GAUR, A., 2023. Decoupling in international business: Evidence, drivers, impact, and implications for IB research. *Journal of World Business*, 58(1), pp.101399. https://doi.org/10.1016/j.jwb.2022.101399

[11] BRUDNEY, J.J., 2022. Muted Voices: United States Employees' Role in Regulating and Protecting Workplace Health. *Fordham Law Legal Studies Research Paper*, (4151970). https://cllpj.law.illinois.edu/ ISSN 1095-6654

[12] CHO, S., KIM, S., LEE, H.W. & LI, Z.A., 2023. You make me anxious! Witnessing safety violations during the daily commute and at work leads to employee work withdrawal. *Human Resource Management*, 63(2), pp.207–223. https://doi.org/10.1002/hrm.22197

[13] JOE-ASARE, T., STEMN, E. & AMEGBEY, N., 2022. 444 Nature of past remedial measures: the case of Ghanaian mining industry. *Injury prevention*, 28(2), pp. A67. DOI:10.1136/injuryprev-2022-safety2022.200

[14] REASON, J., 1990. *Human Error*. Cambridge: Cambridge University Press.

[15] RASMUSSEN, J., 1986. *Information Processing and Human -Machine*. New York, USA: North-Holland.

[16] PRIOR, A. T., 2022. "Ergonomic Safety in Supply Chains". Doctoral Dissertations and Projects. Available at https://digitalcommons.liberty.edu/doctoral/3993 [Accessed 12 December 2023].

[17]TAUFEK, F.H.B.M., ZULKIFLE, Z.B. & KADIR, S.Z.B.A., 2016. Safety and Health Practices and Injury Management in Manufacturing Industry. *Procedia Economics and Finance*, 35, pp.705–712. https://doi.org/10.1016/S2212-5671(16)00088-5

[18]DERDOWSKI, L.A. & MATHISEN, G.E., 2023. Psychosocial factors and safety in high-risk industries: A systematic literature review. *Safety science*, 157, p.105948. https://doi.org/10.1016/j.ssci.2022.105948

[19]BAYRAMOVA, A., EDWARDS, D.J., ROBERTS, C. & RILLIE, I., 2023. Constructs of leading indicators: A synthesis of safety literature. *Journal of safety research*, 85, pp. 469-484. https://doi.org/10.1016/j.jsr.2023.04.015

[20]WONG, E.T. & MAN, W.Y., 2023. Smart Maintenance and Human Factor Modeling for Aircraft Safety. In *Applications in Reliability and Statistical Computing*. Cham: Springer International Publishing.

[21]SAHOO, S. & LO, C.Y., 2022. Smart manufacturing powered by recent technological advancements: A review. *Journal of Manufacturing Systems*, 64, pp.236-250. https://doi.org/10.1016/j.jmsy.2022.06.008

[22]LEK, K.L., CHU, J., HORSEY, E.M., WANG, J. & HUANG, J., 2022. The roles of top management team innovation orientation and institutional support on organisational learning and innovation performance. *Science, Technology and Society*, 27(4), pp.587-610. https://doi.org/10.1177/09717218221125009

[23]IBRAHIM, K., SIMPEH, F. AND ADEBOWALE, O.J., 2023. Benefits and challenges of wearable safety devices in the construction sector. *Smart and Sustainable Built Environment*, Vol (ahead of print), No. (ahead of print). https://doi.org/10.1108/SASBE-12-2022-0266

[24]GALIANO, M.A., FERGUSSON, M.E.M., GUERRERO, W.J., MUÑÓZ, M.F., BASTO, G.A.O., RAMÍREZ, J.S.C., LOZANO, M.G. & SUNDT, A.L., 2023. Technological innovation for workload allocation in nursing care management: an integrative review. *F1000Research*, 12(104), p.104. https://doi.org/10.12688%2Ff1000research.125421.3

[25]ONIFADE, M., ADEBISI, J.A., SHIVUTE, A.P. & GENC, B., 2023. Challenges and applications of digital technology in the mineral industry. *Resources Policy*, 85, p.103978. https://doi.org/10.1016/j.resourpol.2023.103978

[26]LISHCHUK, V. & PETTERSSON, M., 2021. The mechanisms of decision-making when applying geometallurgical approach to the mining industry. *Mineral Economics*, 34, pp.71-80. https://doi.org/10.1007/s13563-020-00220-9

[27]WANG, J., FAN, Y. & NIU, Y., 2022. Routes to failure: Analysis of chemical accidents using the HFACS. *Journal of Loss Prevention in the Process Industries*, 75, pp. 104695. https://doi.org/10.1016/j.jlp.2021.104695

[28]QI, H., ZHOU, Z., IRIZARRY, J., LIN, D., ZHANG, H., LI, N. & CUI, J., 2024. Automatic Identification of Causal Factors from Fall-Related Accident Investigation Reports Using Machine Learning and Ensemble Learning Approaches. *Journal of Management in Engineering*, 40(1), p.04023050. https://doi.org/10.1061/JMENEA.MEENG-548

[29]ARZAHAN, I.S.N., ISMAIL, Z. AND YASIN, S.M., 2022. Safety culture, safety climate, and safety performance in healthcare facilities: a systematic review. *Safety science*, 147, pp.105624. https://doi.org/10.1016/j.ssci.2021.105624

[30]ROSANDER, M. & SALIN, D., 2023. A hostile work climate and workplace bullying: reciprocal effects and gender differences. *Employee Relations: The International Journal*, 45(7), pp.46-61. https://doi.org/10.1108/ER-03-2022-0127

[31]KHAN, R.U., YIN, J., MUSTAFA, F.S. & FAREA, A.O.A., 2022. A data centered human factor analysis approach for hazardous cargo accidents in a port environment. *Journal of Loss Prevention in the Process Industries*, 75, pp.104711. https://doi.org/10.1016/j.jlp.2021.104711

[32]BHUIYAN, M.R.H., IBTIHAL, S.A. & NOKSHI, K.N., 2023. Involvement of human and organizational factors in railway accidents: application of the human factors analysis and classification system and

Bayesian network. *Transportation Research Record*, 2677(8), pp.496-508. https://doi.org/10.1177/03611981231156932

[33]YANG, L., WANG, X., ZHU, J. & QIN, Z., 2022. Risk factors identification of unsafe acts in deep coal mine workers based on grounded theory and HFACS. *Frontiers in public health*, 10, pp.852612. https://doi.org/10.3389/fpubh.2022.852612

[34]MOLLO, L.G., EMUZE, F. AND SMALLWOOD, J., 2023. *Training-Within-Industry Job Programs for Improved Construction Safety*. Taylor & Francis.

[35]LAWANI, K., HARE, B., TONG, M. & CAMERON, I., 2023. Exploring mental health challenges and implications for construction safety. *Journal of Engineering, Design and Technology*, Vol (ahead of print), No. (ahead of print). https://doi.org/10.1108/JEDT-07-2023-0327

[36]WU, B., KOU, L. & MA, Q., 2017. Research on HFACS Based on Accident Causality Diagram. Open *Journal of Safety Science and Technology*, 7, pp. 77-85. https://doi.org/10.4236/ojsst.2017.72007

[37]OLSON, J. A. & RAZ, A., 2021. Applying insights from magic to improve deception in research: The Swiss cheese model. *Journal of Experimental Social Psychology*, 92, pp. 104053. https://doi.org/10.1016/j.jesp.2020.104053

[38]KARIMI, A., ABBASI, M., ZOKAEI, M. & FALAHATI, M., 2021. Development of leading indicators for the assessment of occupational health performance using Reason's Swiss cheese model. *Journal of education and health promotion*, Volume 10, pp. 158. DOI: 10.4103/jehp.jehp_1326_20

[39]MCKINNON, R.C., 2023. *The Cause, Effect, and Control of Accidental Loss*. CRC Press.

[40]KINMAN, G. & GRANT, C., 2021. Presenteeism during the COVID-19 pandemic: risks and solutions. *Occupational medicine*, 71(6-7), pp. 243-244. https://doi.org/10.1093/occmed/kqaa193

[41]CAFFERKEY, K., HARNEY, B., TOWNSEND, K. & WINTERTON, J., 2021. Guest editorial: Human capital, "high involvement and well-being: assessing progress and advancing understanding". *Employee relations*, 43(4), pp. 829-841. https://dx.doi.org/10.1108/ER-06-2021-545

[42]STRATTON, E., CHOI, I., PETERS, D., CALVO, R.A., HARVEY, S.B. & GLOZIER, N., 2020. Co-Designing a Web-Based Decision Aid Tool for Employees Disclosure of Mental Health Conditions: A Participatory Study Design Using Employee and Organizational Preferences. *JMIR Formative Research*, 4(11), p. e23337. https://doi.org/10.2196/23337

[43]IVASCU, L., SARFRAZ, M., MOHSIN, M., NASEEM, S. & OZTURK, I., 2021. The Causes of Occupational Accidents and Injuries in Romanian Firms: An Application of the Johansen Cointegration and Granger Causality Test. International *Journal of Environ. Res. Public Health*, Volume 18, pp. 7634. https://doi.org/10.3390/ijerph18147634

[44]TETZLAFF, E.J., GOGGINS, K.A., PEGORARO, L.A., DORMAN, S.C., PAKALNIS, V. & EGER, T.R., 2021. Safety Culture: A Retrospective Analysis of Occupational Health and Safety Mining Reports. *Safety and Health at Work*, 12, pp. 201-208. https://doi.org/10.1016/j.shaw.2020.12.001

[45]BARKHORDARI, A., MALMIR, B. & MALAKOUTIKHAH, M., 2019. An analysis of individual and Social Factors Affecting Occupational Accidents. *Safety and Health at Work*, 10, pp. 205-212. https://doi.org/10.1016/j.shaw.2019.01.002

[46]BASIAS, N. & POLLALIS, Y., 2018. Quantitative and qualitative research in business & technology: Justifying a suitable research methodology. *Review of Integrative Business and Economics Research*, 7, pp.91-105. https://buscompress.com/riber-7-s1.html ISSN: 2304-1013

[47]BOUGIE, R. AND SEKARAN, U., 2019. *Research methods for business: A skill building approach*. John Wiley & Sons.

[48]YILMAZ, K., 2013. Comparison of quantitative and qualitative research traditions: Epistemological, theoretical, and methodological differences. *European journal of education*, 48(2), pp.311-325. https://doi.org/10.1111/ejed.12014

[49]FLICK, U. ed., 2013. *The SAGE handbook of qualitative data analysis*. Sage Publications.

[50]RAHI, S., 2017. Research design and methods: A systematic review of research paradigms, sampling issues and instruments development. *International Journal of Economics and Management Sciences*, 6(2), 1000403. DOI: 10.4172/2162-6359.1000403

[51]SAUNDERS, M., LEWIS, P. & THORNHILL, A., 2019. Understanding research philosophy and approaches to theory development. In: *Research Methods for Business Students*. 8 ed. Harlow: Pearson Education Limited.

[52]MIDDLETON, F., 2023. *Reliability vs validity in research*. Available at: https://www.scribbr.com/methodology/reliability-vs-validity/ [Accessed 12 December 2023].

[53]ANNEY, V.N., 2014. Ensuring the Quality of the Findings of Qualitative Research: Looking at Trustworthiness Criteria. *Journal of Emerging Trends in Educational Research and Policy Studies (JETERAPS)*, 5(2) pp. 272-281. ISSN: 2141-6990

[54]TUBIS, A., WERBIŃSKA-WOJCIECHOWSKA, S. & WROBLEWSKI, A., 2020. Risk Assessment Methods in Mining Industry—A Systematic Review. *Applied Sciences*, 10, pp. 51-72. https://doi.org/10.3390/app10155172

[55]SCHWATKA, N., TENNEY, L., BROCKBANK, C. & NEWMAN, L. S., 2017. Chronic Conditions, Workplace Safety, And Job Demands Contribute to Absenteeism and Job Performance. *Health Affairs*, 2(36), pp. 237-244. https://doi.org/10.1377/hlthaff.2016.1151

[56]XIE, J., LI, S. & WANG, X., 2022. A digital smart product service system and a case study of the mining industry: MSPSS. *Advanced Engineering Informatics*, 53, pp.101694. https://doi.org/10.1016/j.aei.2022.101694

[57]GORAKHKI, M.H. & BAREITHER, C.A., 2017. Sustainable reuse of mine tailings and waste rock as water-balance covers. *Minerals*, 7(128), pp.1-17. https://doi.org/10.3390/min7070128

[58]PHILLIPS, R.O., KECKLUND, G., ANUND, A. & SALLINEN, M., 2017. Fatigue in transport: a review of exposure, risks, checks and controls. *Transport reviews*, 37(6), pp.742-766. https://doi.org/10.1080/01441647.2017.1349844