Analysis of occupational accident profiles in mining activities in the state of Espírito Santo, Brazil

Análise do perfil de acidentes de trabalho em atividades de mineração no estado do Espírito Santo, Brasil

Análisis del perfil de accidentes laborales en actividades mineras en el estado de Espírito Santo, Brasil

Rômulo Furtado Faria
Master in Energy
Institution: Instituto Federal de Educação, Ciência e Tecnologia do Espírito Santo (IFES)
Address: Nova Venécia, Espírito Santo, Brazil
E-mail: romulo.faria@ifes.edu.br

Lincoln Ribeiro Maia de Resende
Master in Mineral Engineering
Institution: Instituto Federal de Educação, Ciência e Tecnologia do Espírito Santo (IFES)
Address: Nova Venécia, ES, Brazil
E-mail: lincoln.resende@ifes.edu.br

Cássio Furtado Lima
Master in Forestry Science
Institution: Instituto Federal de Educação, Ciência e Tecnologia do Pará (IFPA)
Address: Ananindeua, Pará, Brazil
E-mail: cassio.lima@ifpa.edu.br

Luciano José Minette
Doctor in Forest Sciences
Institution: Universidade Federal de Viçosa (UFV)
Address: Viçosa, Minas Gerais, Brazil
E-mail: minette@ufv.br

Leonardo França da Silva
Doctor in Agricultural Engineering
Institution: Universidade Federal da Grande Dourados
Address: Dourados, Mato Grosso do Sul, Brazil
E-mail: leonardo.silva@ufv.br

Stanley Schettino
Doctor in Forest Sciences
Institution: Universidade Federal de Minas Gerais (UFMG)
Address: Montes Claros, Minas Gerais, Brazil
E-mail: schettino@ufmg.br

Francisco de Assis Costa Ferreira
Master in Forest Sciences
Institution: Universidade Federal de Viçosa (UFV)
Address: Viçosa, Minas Gerais, Brazil
E-mail: assiscferreira@gmail.com

Eliza Rocha Fernandes Furtado
Specialist in Quality Management and Technology
Institution: Secretaria de Saúde de Nova Venécia
Address: Nova Venécia, Espírito Santo, Brazil
E-mail: elizarfernandes@gmail.com

Nayara Kelly Feitosa Ferreira
Master in Agronomy
Institution: Instituto Federal de Educação, Ciência e Tecnologia do Pará (IFPA)
Address: Santarém, Pará, Brazil
E-mail: nayara.ferreira@ifpa.edu.br

Michel Keisuke Sato
Doctor in Agronomy
Institution: Instituto Federal de Educação, Ciência e Tecnologia do Pará (IFPA)
Address: Castanhal, Pará, Brazil
E-mail: michel.sato@ifpa.edu.br

Bruna Naiara Rocha Garcia
Master in Forestry Science
Institution: Instituto Federal de Educação, Ciência e Tecnologia do Pará (IFPA)
Address: Óbidos, Pará, Brazil
E-mail: bruna.garcia@ifpa.edu.br

Angleson Figueira Marinho
Master in Food Science and Technology
Institution: Instituto Federal de Educação, Ciência e Tecnologia do Pará (IFPA)
Address: Bragança, Pará, Brazil
E-mail: angleson.marinho@ifpa.edu.br

Paulo Ivan Lima de Andrade
Master in Forest Sciences
Institution: Instituto Federal de Educação, Ciência e Tecnologia do Pará (IFPA)
Address: Castanhal, Pará, Brazil
E-mail: paulo.andrade@ifpa.edu.br

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Mateus Xavier Lima Machado
Forestry Engineer
Institution: Universidade Federal de Viçosa (UFV)
Adress: Viçosa, Minas Gerais, Brazil
E-mail: mateus.xavier@ufv.br

Fernanda Araujo Lima
Doctor Applied Biochemistry
Institution: Centro Estadual de Atenção Especializada de Viçosa
Address: Viçosa, Minas Gerais, Brazil
E-mail: fernanda.oaufv@yahoo.com.br

ABSTRACT

The state of Espírito Santo stands out in the mineral sector as Brazil's leading exporter of ornamental stones. Despite the sector's economic importance, there is a notable lack of scientific research focused on this area, particularly regarding occupational safety. In this context, the primary objective of this study is to analyze the profile of occupational accidents in mining activities in Espírito Santo from 2017 to 2021. This analysis is crucial as it can serve as a foundation for guiding future studies and initiatives that promote best practices in health and safety. The methodology involved a case study approach, based on the collection and analysis of occupational accident notifications using public data from the "SmartLab" platform. The research results allowed for the identification of key findings, including the geographic distribution of occupational accidents, economic sectors with the highest number of notifications, the most common injuries in the mining sector, the most affected body parts, and the primary causal agents. Mining activities were found to have the highest number of fatalities compared to other sectors in the state, with a rising trend in fatal accidents over time. This highlights the urgent need for targeted actions and awareness campaigns to educate stakeholders in the sector, aiming to reduce the number of accidents.

Keywords: Mining. Occupational Safety. Ergonomics. Occupational Health.

RESUMO

O Estado do Espírito Santo se destaca no setor mineral como principal exportado de rochas ornamentais do país. Apesar da importância do setor para e economia, observa-se uma carência de pesquisas científicas voltadas para esse setor, principalmente relacionado a segurança do trabalho. Diante desse contexto, o trabalho tem como objetivo principal analisar o perfil dos acidentes de trabalho ocorridos em atividades de mineração no Espírito Santo, de 2017 a 2021. Essa análise mostra-se relevante uma vez que pode servir de base para orientar estudos e ações futuras que incentivem boas práticas de saúde e segurança. A metodologia foi composta por um estudo dividido em etapas. A caracteriza como um estudo de caso ao qual foi baseado na coleta e análise do banco de dados das notificações de acidentes de trabalho por meio de dados públicos da plataforma "SmartLab". A partir dos resultados da pesquisa, foi possível

identificar: Distribuição Geográfica dos Acidentes de Trabalho, setores econômicos com mais notificações, lesões mais frequentes no setor de mineração, partes do corpo mais atingidas e principais grupos de agentes causadores. A atividade de Mineração possui maior número de óbitos se comparado com outros setores no estado, constata-se uma tendência de aumento no número de acidentes fatais com óbitos. Enfim observou a necessidade de realizar ações e campanhas de conscientização com intuito de conscientizar a todos do setor afim de reduzir o número de acidentes no setor.

Palavras-chave: Mineração. Segurança do Trabalho. Ergonomia. Saúde Ocupacional.

RESUMEN

El estado de Espírito Santo se destaca en el sector mineral como el principal exportador de piedras ornamentales de Brasil. A pesar de la importancia económica del sector, se observa una notable carencia de investigaciones científicas enfocadas en esta área, especialmente en lo relacionado con la seguridad laboral. En este contexto, el objetivo principal de este estudio es analizar el perfil de los accidentes laborales ocurridos en actividades mineras en Espírito Santo entre 2017 y 2021. Este análisis es fundamental, ya que puede servir como base para orientar futuros estudios e iniciativas que promuevan buenas prácticas en salud y seguridad. La metología consistió en un estudio de caso, basado en la recopilación y análisis de las notificaciones de accidentes laborales mediante datos públicos de la plataforma "SmartLab". Los resultados de la investigación permitieron identificar hallazgos clave, como la distribución geográfica de los accidentes laborales, los sectores económicos con mayor número de notificaciones, las lesiones más comunes en el sector minero, las partes del cuerpo más afectadas y los principales agentes causales. Se encontró que las actividades mineras tienen el mayor número de muertes en comparación con otros sectores en el estado, con una tendencia al aumento de accidentes fatales a lo largo del tiempo. Esto resalta la necesidad urgente de implementar acciones y campañas de concienciación dirigidas a los actores del sector, con el objetivo de reducir el número de accidentes.

Palabras clave: Minería. Seguridad Laboral. Ergonomía. Salud Ocupacional.

1 INTRODUCTION

The topic of occupational safety is a critical issue that spans all sectors and areas of the economy. In Brazil, the mineral sector plays a pivotal role in the national economy. Reflecting this importance, the state of Espírito Santo, according to Brazilian Association of the Ornamental Stone Industry (2022), along with Minas Gerais and Ceará, stands out as one of the leading exporters

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of ornamental stones in the country. Espírito Santo and Minas Gerais alone account for 93.2% of Brazil's total export revenue in this sector, generating USD 1.10 billion and USD 132.8 million, respectively.

Despite the significant contributions of mining to societal and economic development, the sector demands increased attention to occupational health and safety. The global demand for companies to adopt sustainable practices, encompassing economic, ecological, and social dimensions, is steadily rising (Furtado Lima *et al.*, 2024). Within this context, ensuring the occupational health and well-being of workers, particularly in the mining industry, has become increasingly essential, underscoring the need for targeted measures to enhance safety and sustainability in this high-risk sector.

Concerns about occupational accidents in the mining sector are not exclusive to Brazil. Internationally, there have been studies analyzing accidents in large quarries, which reported higher incident rates. The implementation of occupational management programs was crucial in promoting the health and well-being of workers (Sanmiquel *et al.*, 2014). It is important to emphasize that systematic investigation of accidents is essential for risk assessment, and this approach has enabled mining operations to critically evaluate how effectively they manage the risks faced by their workers (Joy, 2004). In this context, the study by Lima *et al.* (2019) demonstrated that improving the occupational health of heavy machinery operators led to a reduction in critical incidents, also known as near-miss accidents, within the company. This highlights the importance of proactive health and safety measures in mitigating risks and enhancing overall safety performance in the mining sector.

According to Santos *et al.* (2017), safety and health in mining hold significant value within companies, as they emphasize that the best way to prevent accidents is through proactive measures. This not only directly impacts the company's commitments but also the lives of its employees, who are key assets to the organization. Occupational safety has now become a strategic approach for companies to remain competitive in the workforce. By prioritizing safety, companies can achieve their objectives, build a strong reputation among their clients, and gain positive recognition within society. This underscores the

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critical importance of a robust safety culture in sustaining both business success and employee well-being.

In recent years, numerous studies have focused on occupational accidents in the mining industry (Lima *et al.*, 2016; Dos Santos Caitano *et al.*, 2021; Gao *et al.*, 2021; Cacciuttolo *et al.*, 2023; Mudzakir *et al.*, 2023; Zhang *et al.*, 2024). These studies identify risk factors related to explosives, machinery, dam failures, drilling, rock cutting, and transportation. As such, research that gathers data on recorded accidents and promotes Occupational Health and Safety (OHS) practices is essential for the mining sector.

Improving safety awareness and consequently reducing accident reports requires easy access to OHS data and information. This is critical for raising awareness, preventing workplace accidents, and fostering a culture of safety. In addition to enhancing understanding of the topic, such data serves as a vital tool for discussing best practices in health and safety, as well as raising awareness in the workplace. These initiatives contribute not only to a reduction in accidents but also to the creation of a more proactive, informed workforce, driving a culture of continuous improvement and higher safety standards in the mining industry.

It becomes evident that in various operations carried out daily in the mining industry, workers are exposed to multiple occupational hazards with significant potential to harm their health and safety, resulting in detrimental effects both for the workers and the companies. In this context, the focus of this research is to analyze the profile of occupational accidents that occurred in mining-related operations in the state of Espírito Santo, Brazil. This study aims to identify key risk factors, assess accident trends, and provide insights into how the sector can improve safety practices and reduce the occurrence of such incidents. By doing so, it seeks to contribute to enhancing occupational health and safety standards within the mining industry in the region.

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2 MATERIALS AND METHODS

2.1 STUDY AREA

This study is characterized as an exploratory research aimed at analyzing all recorded occupational accidents between 2017 and 2021 in mining-related activities in the state of Espírito Santo, Brazil (Figure 1). The methodology adopted is based on the research conducted by Majumder *et al.* (2022), which employs similar insights to promote learning and improvement within the human-machine system.

Figure 1 – Map of the Study Area Location, Espírito Santo, Brazil

Source: Adapted from Braga *et al.* (2018).

The mining sector is understood to encompass all economic activities related to the extraction and processing of mineral resources. Accordingly, based on the National Classification of Economic Activities (CNAE) (IBGE, 2020), the mining-related activities included in this study are:

- Quarrying and other work involving stones;
- Support activities for mineral extraction, excluding petroleum and natural gas;
- Support activities for petroleum and natural gas extraction;

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- Coal mining;
- Gemstone extraction (precious and semi-precious stones);
- Extraction of non-ferrous metallic minerals not specified elsewhere;
- Extraction of non-metallic minerals not specified elsewhere;
- Extraction of minerals for the production of fertilizers, chemicals, and other products;
- Tin mining;
- Iron ore extraction;
- Petroleum and natural gas extraction;
- Extraction and refining of sea salt and rock salt;
- Drilling and exploration activities.

This classification highlights the diverse range of activities within the mining sector and underscores the importance of addressing occupational health and safety within each of these subfields to mitigate risks and enhance safety practices.

2.2 RESEARCH STAGES AND STATISTICAL ANALYSES

The methodology of the study consisted of two main stages. The first stage involved conducting an extensive literature review on occupational health and safety, focusing specifically on mining operations and their associated risks. The second stage was centered on the collection and analysis of accident notification data. The primary data source for this study was the Occupational Safety and Health Observatory on the SmartLab Platform (SMARTLAB, 2020). SmartLab is a collaborative initiative between the Public Ministry of Labor and the International Labour Organization, which aggregates raw public data from numerous sources, compiles, organizes, and processes it to provide detailed insights (SMARTLAB, 2020).

The profile of occupational accidents related to mining activities in Espírito Santo from 2017 to 2021 was analyzed using the data and filters available on SmartLab. The platform allows for in-depth analysis of the most frequent injuries, the body parts most affected, the types of causative agents, and the occupations with

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the highest number of recorded accidents. It is important to highlight that the information in SmartLab pertains to notifications of Work Accident Communications (CAT) within the population of employees with formal employment contracts, providing a comprehensive overview of workplace incidents.

To further enhance the analysis, statistical tools were applied to identify patterns, trends, and correlations within the data, with particular emphasis on risk factors specific to the mining sector. The results were then compiled and presented through a series of charts and tables to facilitate a clearer understanding of the occupational accident profile in Espírito Santo's mining industry. Microsoft Office and GraphPad Prism 8 software were utilized for statistical analysis and inference, employing both descriptive statistics and inferential techniques such as hypothesis testing, regression analysis, and trend analysis to provide robust insights and enhance the reliability of the findings. This approach allowed for a thorough interpretation of the data, which is crucial for identifying key areas of intervention to improve safety practices within the sector.

3 RESULTS AND DISCUSSION

### 3.1 ANALYSIS OF THE DISTRIBUTION OF WORKPLACE ACCIDENT REPORTS

Occupational accidents are among the primary causes of harm to workers' health and well-being, extending their impact beyond individual labor activities to broader societal and economic domains, with substantial social and financial repercussions (Shimizu *et al.*, 2021). In Brazil, the Ministry of Labor is the authoritative body responsible for regulating Occupational Safety and Health (OSH) policies. This is primarily achieved through the enforcement of Regulatory Norms (NRs), which establish clear guidelines delineating the obligations, rights, and responsibilities of both employers and employees. These norms aim to ensure safe and healthy working conditions, effectively mitigating the occurrence of work-related diseases and accidents (Carvalho *et al.*, 2020).

A key requirement for employers, as stipulated in the Social Security Regulation, is the obligation to report work-related accidents or occupational diseases by filing a Work Accident Report (CAT) within one business day following the occurrence (BRASIL, 1999). The CAT represents the most critical source of official data on occupational accidents in Brazil, serving as a cornerstone for evaluating and addressing workplace safety and health.

This system not only underpins the monitoring of occupational health and safety compliance but also provides valuable insights for shaping public policies aimed at accident prevention and promoting safer work environments.

In this context, Figure 2 depicts the geographical distribution and frequency analysis of Workplace Accident Reports (CATs) within the state of Espírito Santo, Brazil. The visualization employs a color gradient to enhance interpretability, where darker shades indicate higher frequencies of reported accidents. Notably, the municipalities with the highest number of reported CATs are Serra, Vitória, Cariacica, Linhares, and Cachoeiro de Itapemirim. This distribution highlights the concentration of workplace accidents in regions with greater economic activity and industrial development, which may be associated with a higher density of labor-intensive industries or less stringent safety protocols. The use of a geospatial representation underscores the importance of targeted interventions and resource allocation to reduce the prevalence of workplace accidents in these high-risk areas.

Figure 2 – Geographical Distribution and Frequency Analysis of Workplace Accident Reports (CATs) in Espírito Santo, Brazil.
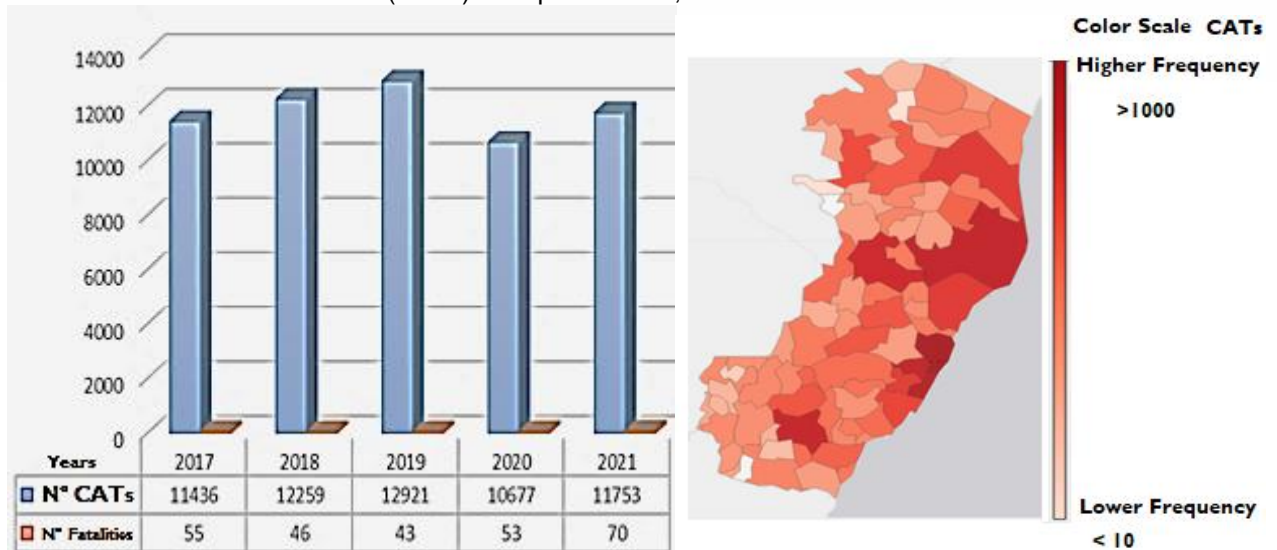
Source: Prepared by the Authors (2024). Data on Work Accident Reports (CATs) from 2017 to 2021, Espírito Santo, Brazil (SMARTLAB, 2020).

Between 2017 and 2019, there was a noticeable increase in the number of Workplace Accident Reports (CATs). However, in 2020, a significant reduction was observed, which may be attributed to the COVID-19 pandemic. The pandemic imposed a range of restrictions across various economic sectors, including the mineral sector, likely influencing the decline in reported accidents.

In contrast, the number of fatalities due to workplace accidents showed a concerning trend. The sector experienced a marked increase in fatal accidents, reaching an alarming total of 70 fatalities in 2021. A comparative analysis reveals an inversely proportional relationship: the year with the highest number of CATs corresponded to the lowest fatality rate. This inverse trend underscores the complexity of workplace safety dynamics, suggesting that increased reporting of non-fatal accidents may coincide with a heightened focus on safety measures, potentially mitigating the severity of incidents.
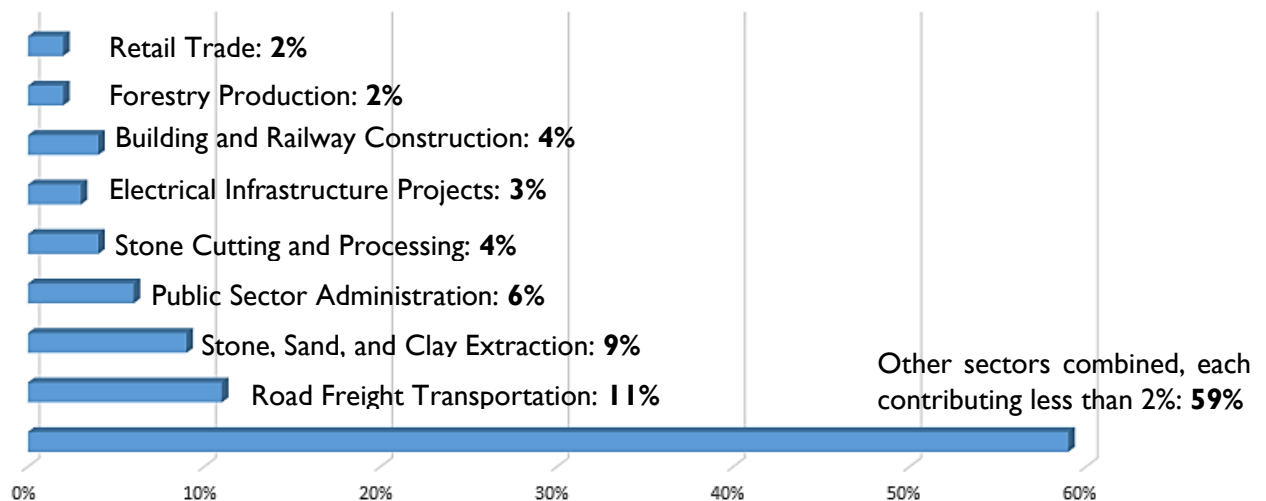
Further studies with larger sample sizes are recommended to provide a deeper understanding of the distribution and causative factors of workplace accidents and fatalities. Expanding the scope of analysis could shed light on systemic issues and guide the implementation of effective safety interventions.

As highlighted by Lima *et al.* (2024), improving working conditions not only fosters safer and more secure operations but also translates into substantial

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operational gains. Enhanced safety measures and ergonomics play a pivotal role in minimizing risks, improving worker well-being, and boosting overall productivity in labor-intensive industries.

Figure 3 illustrates the distribution of fatal workplace accidents across economic sectors in Espírito Santo, Brazil. The data reveals an intriguing pattern: the road freight transportation sector emerges as a significant contributor. This sector, while not directly classified under mining activities, is closely connected to the mining industry, as all mineral production in the state is transported by truck. Consequently, any roadway accident involving a truck carrying stone or ore is recorded under the road freight transportation category, highlighting its indirect link to mining operations.

Figure 3 – Distribution of Economic Sectors with Reported Fatalities in Espírito Santo, Brazil.

- Retail Trade: **2%**
- Forestry Production: **2%**
- Building and Railway Construction: **4%**
- Electrical Infrastructure Projects: **3%**
- Stone Cutting and Processing: **4%**
- Public Sector Administration: **6%**
- Stone, Sand, and Clay Extraction: **9%**
- Road Freight Transportation: **11%**

Other sectors combined, each contributing less than 2%: **59%**

Source: Prepared by the Authors (2024). Data on Work Accident Reports (CATs) from 2017 to 2021, Espírito Santo, Brazil (SMARTLAB, 2020).

Additionally, Figure 3 underscores the direct involvement of mining-related activities in workplace fatalities. Two sectors with notable percentages are stone, sand, and clay extraction, accounting for 9% of fatalities, and stone cutting and processing, contributing 4%. Together, these two sectors represent 13% of workplace fatalities, surpassing the 11% attributed to the road freight transportation sector. This finding underscores the critical safety challenges inherent in mining operations and their associated processes.

The data presented in Figure 3 reinforces the urgent need for targeted public policies and awareness programs within the broader mining sector. Such initiatives should aim to address systemic risks, promote safer work environments, and reduce the high prevalence of fatal accidents. The significant representation of mining-related sectors in workplace fatalities emphasizes the necessity for stricter safety regulations, enhanced training programs, and industry-wide commitment to occupational health and safety standards.

This scenario serves as a stark reminder of the critical role proactive safety measures and comprehensive monitoring play in preventing accidents and protecting workers' lives in high-risk industries like mining.

According to the study by Ferrari *et al.* (2023), the rising global temperatures are anticipated to significantly impact the frequency of Workplace Accident Reports (CATs) in various sectors, with mining being one of the most affected industries. The increase in temperature can exacerbate hazardous working conditions, particularly in physically demanding sectors such as mining, construction, and road freight transportation. These industries often involve workers operating in extreme conditions, which can lead to higher levels of heat stress, fatigue, and physical strain. Such factors compromise both worker safety and performance.

In light of these challenges, it is crucial to prioritize the improvement of ergonomic well-being by enhancing working conditions, particularly in sectors vulnerable to climate-related stressors. Effective ergonomic interventions, such as better personal protective equipment, improved worksite design, and climate-controlled environments, can reduce the adverse effects of rising temperatures. Moreover, the development of robust indicators to assess safety, comfort, and overall worker health is essential. As noted by Lima *et al.* (2024), these indicators will enable more accurate monitoring of working conditions, fostering a safer and more comfortable work environment. This proactive approach will help minimize accidents, reduce the negative impact of environmental stress, and promote the long-term health and productivity of workers across sectors like mining and outhers.

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3.2 ANALYSIS OF OCCUPATIONAL INJURY PATTERNS AND ACCIDENT-CAUSING FACTORS IN MINING OPERATIONS
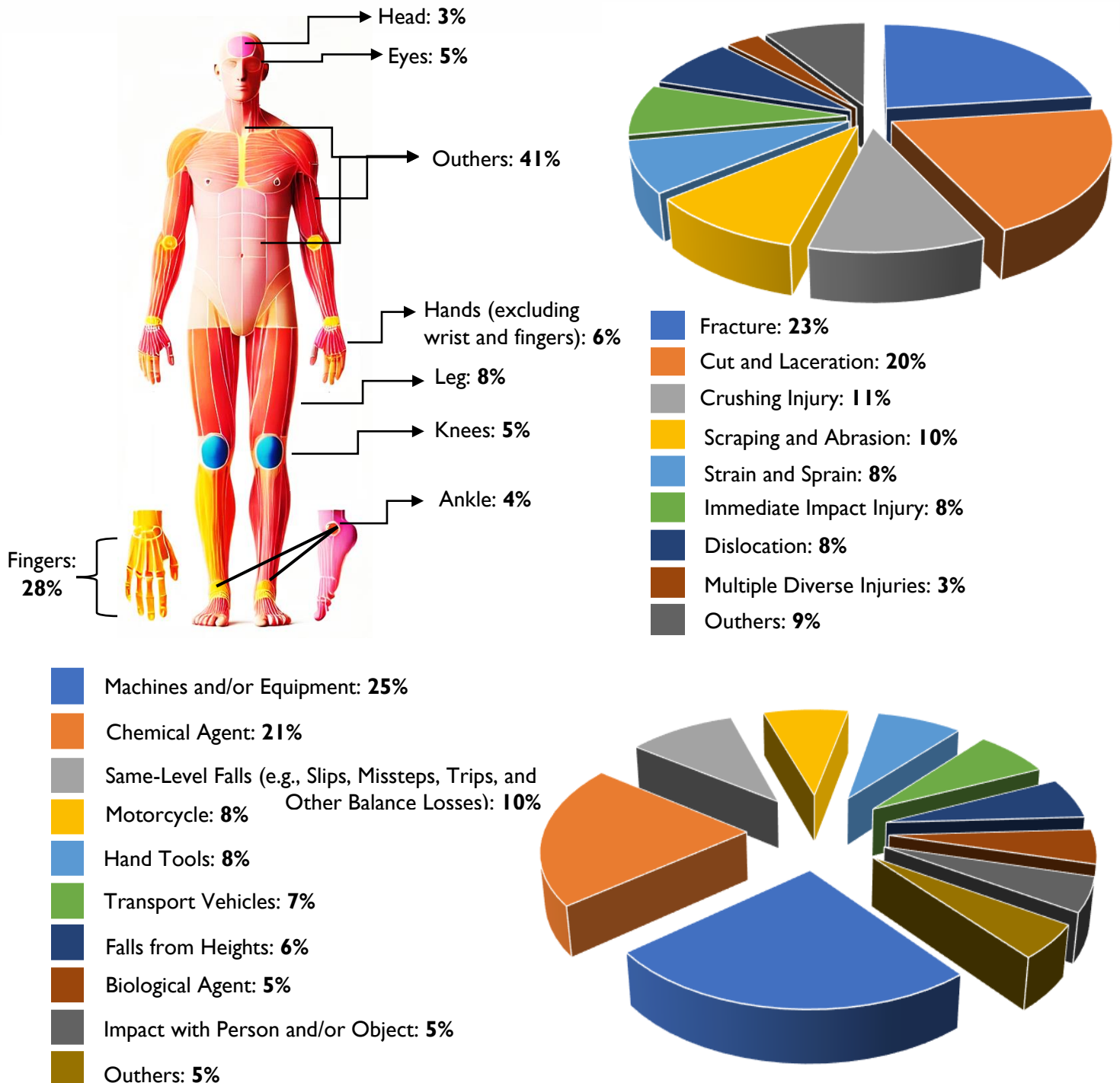
Figure 4 illustrates the Analysis of Occupational Injury Patterns and Accident-Causing Factors in Mining Operations. The most frequent injuries associated with Accident Communication Reports (CATs) in the mining sector are fractures, accounting for 23%, followed by cuts and lacerations at 20%, and contusions or crush injuries at 11%. These figures reflect the hazardous nature of mining activities, where workers often operate in close proximity to heavy machinery and large-scale equipment in challenging field environments.

The prevalence of such injuries underscores the inherent risks associated with mining operations, which consistently rank among the highest-risk industries worldwide. The physically demanding nature of the tasks, combined with exposure to dynamic and unpredictable working conditions and the necessity of interacting directly with powerful industrial machinery, significantly contributes to this injury profile.

Furthermore, the high frequency of fractures, lacerations, and crush-related injuries correlates with the sector's classification as a high-risk industry. This emphasizes the urgent need for comprehensive safety protocols, regular workforce training, and the integration of advanced protective and ergonomic technologies. Addressing the challenges of human-machine interaction is critical to reducing workplace accidents and enhancing safety, ergonomics, and the overall well-being of employees in this sector (Schettino *et al.*, 2022).

The high incidence of accidents involving fingers and hands represents a common pattern observed in occupational injury records both in Espírito Santo and across Brazil. According to data from SmartLab (2022), between 2017 and 2021, the majority of work-related accidents reported in Brazil's mining sector affected the fingers and hands of workers.

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Figure 4 – Diagnosis of Occupational Injury Patterns and Accident-Causing Factors in Mining Operations in Espírito Santo, Brazil

Head: **3%**
Eyes: **5%**
Outhers: **41%**
Hands (excluding wrist and fingers): **6%**
Leg: **8%**
Knees: **5%**
Ankle: **4%**
Fingers: **28%**

Fracture: **23%**
Cut and Laceration: **20%**
Crushing Injury: **11%**
Scraping and Abrasion: **10%**
Strain and Sprain: **8%**
Immediate Impact Injury: **8%**
Dislocation: **8%**
Multiple Diverse Injuries: **3%**
Outhers: **9%**

Machines and/or Equipment: **25%**
Chemical Agent: **21%**
Same-Level Falls (e.g., Slips, Missteps, Trips, and Other Balance Losses): **10%**
Motorcycle: **8%**
Hand Tools: **8%**
Transport Vehicles: **7%**
Falls from Heights: **6%**
Biological Agent: **5%**
Impact with Person and/or Object: **5%**
Outhers: **5%**

Source: Prepared by the Authors (2024). Data on Work Accident Reports (CATs) from 2017 to 2021, Espírito Santo, Brazil (SMARTLAB, 2020).

In the specific context of mining activities in Espírito Santo during the same period, the data reveal that 28% of reported injuries involved fingers, 8% affected the legs, and 6% involved the hands, as illustrated in Figure 4. These statistics underscore critical vulnerabilities in these anatomical regions, which are frequently exposed to occupational hazards in the mining industry.

Figure 4 also highlights the causative agents of occupational accidents under study. Machines and equipment were responsible for 25% of incidents, followed by chemical agents at 21% and falls on the same level at 10%. This data points to the urgent need for increased attention from both companies and employees regarding the operation of machinery and equipment. To mitigate this scenario, it is essential to intensify training programs on the safe use of machinery and equipment, aligning with standards such as NR-12, which outlines safety protocols for machine operation and risk management.

These findings provide a foundation for guiding institutional policies in workplace health and safety (SST) programs within Espírito Santo. By addressing these specific risks, companies can significantly reduce the frequency and severity of accidents. Additionally, proper use of Personal Protective Equipment (PPE) plays a crucial role in preventing many injuries. It is important to emphasize that, in accordance with legal requirements, employers are obligated to provide appropriate PPE based on the nature of the task and the agents to which employees are exposed, while employees are equally obligated to use the provided equipment correctly.

By implementing robust safety measures, including enhanced PPE protocols, improved training initiatives, and adherence to operational safety standards, companies can foster a safer working environment, thereby promoting employee well-being and operational efficiency.

These types of injuries and contributing factors to workplace risk generation are not exclusive to mining activities. For several years, this scenario has been a highly debated topic in the specialized literature (Tomazin & Benatti, 2001; Minette *et al.*, 2007; Souza *et al.*, 2008; Oliveira *et al.*, 2013; Lima *et al.*, 2019; Schettino *et al.*, 2022; Lima *et al.*, 2023; Lima *et al.*, 2024).

Hand and finger traumas carry diverse implications, extending beyond occupational settings. For a long time, injuries involving these body parts have been recognized as leading causes of functional disability. According to Souza *et al.* (2008), such injuries can temporarily or permanently limit an individual's ability to perform basic daily tasks, such as eating or maintaining personal hygiene. This highlights the critical need for preventive measures, as these injuries not only affect productivity but also impair quality of life.

The results depicted in Figure 4 align with the findings of Santos and Almeida (2016), who emphasize that major workplace accidents have a direct impact on the affected body parts. Moreover, the study underscores the necessity of implementing protective measures tailored to professionals engaged in mining activities to prevent such incidents. These measures may include advanced training, improved ergonomic designs, and the use of personal protective equipment (PPE).

Future research should aim to categorize accidents based on the specific operations performed in mining activities. This approach would facilitate the development of targeted risk mitigation strategies, ensuring that interventions are appropriately designed for each task. By focusing on the nuances of individual mining processes, it would be possible to enhance safety standards and reduce the prevalence of occupational injuries. Furthermore, integrating technological advancements, such as automation and monitoring systems, could significantly improve workplace safety, ultimately benefiting both workers and the overall efficiency of mining operations.

The research provided significant insights into health and safety dynamics in mining operations within the State of Espírito Santo. It offered a comprehensive understanding of a complex topic, emphasizing worker-related issues and delivering a range of positive outcomes regarding awareness and dissemination. The data presented in this study clearly outline the occupational health and safety landscape in the mining sector, which remains a critical area of concern due to its higher fatality rates compared to all other economic sectors in the state. This situation underscores the urgent need for strategic advancements to overcome barriers and facilitate meaningful improvements in this scenario.

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4 CONCLUSIONS

The findings revealed a correlation between population density and the frequency of workplace accident notifications (CATs), with more populous cities reporting higher numbers of incidents. However, sectors directly and indirectly linked to mining consistently exhibit the highest fatality rates. These findings highlight the pressing need for intensified training programs aimed at workforce capacity building, alongside the rigorous enforcement of safety standards for machinery and equipment. Additionally, the adoption of advanced technologies focused on automation and mechanization should be prioritized to mitigate risks and improve operational safety.

Another critical aspect of the study pertains to the types of injuries sustained. Fractures emerged as the most prevalent, accounting for 23%, followed by cuts and lacerations at 20%, and contusions and crush injuries at 11%. The analysis also highlighted the most affected body parts, with fingers leading at 28%, followed by legs at 8%, and hands at 6%. The primary causal agents of these injuries were identified as machinery and equipment (25%), chemical agents (21%), and same-level falls (10%).

To address these challenges effectively, companies and government agencies must collaborate to develop and implement targeted training programs focused on occupational health and safety in mining operations. Special emphasis should be placed on the standards and procedures outlined in key regulatory frameworks, including Norma Regulamentadora 11 (Transport, Handling, Storage, and Material Handling), Norma Regulamentadora 12 (Safety in Machinery and Equipment), and Norma Regulamentadora 22 (Occupational Safety and Health in Mining).

The most significant contribution of this research lies in fostering greater awareness among mining workers regarding occupational health and safety. By highlighting key findings such as the geographic distribution of workplace accidents, the economic sectors with the highest notification rates, the most common injuries in the mining sector, the most frequently affected body parts,

and the primary groups of causative agents, this study provides actionable insights that can benefit both society and academia.

For society, the results emphasize the urgent need for targeted awareness campaigns and educational initiatives aimed at reducing workplace accidents and fatalities, particularly in the high-risk mining sector. These initiatives can help inform policy development, improve safety standards, and foster a culture of safety within the industry.

For academia, the research findings contribute to a deeper understanding of occupational hazards in mining and open avenues for further studies to develop innovative interventions, enhance training programs, and advance technological solutions to mitigate risks. This dual impact underscores the critical role of collaborative efforts between researchers, industry stakeholders, and policymakers in addressing the pressing challenges faced by one of the most hazardous industrial sectors.

This study acknowledges its reliance on secondary data, which may not fully capture unreported incidents or contextual nuances, and its focus on a specific region, potentially limiting broader applicability. Future research should incorporate primary data collection and explore comparisons across regions or sectors. Additionally, evaluating the effectiveness of safety interventions and technologies could provide actionable insights for improving workplace safety in mining

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