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Implementation of Occupational Health and Safety Using the Hiradc Method (Hazard Identification, Risk Assessment, and Determining Control) In Mining Areas: Literature Review

[1]Hizrian Al Zhafir, [2]Jopan Nandito, [3]Wahyuni, [4]Indra Ulya

[1,2,3,4]Study Program of Occupational Health and Safety, Faculty of Health Sciences, Teuku Umar University, Indonesia

Corresponding author: Hizrian Al Zhafir; email: rianzhafir1405@gmail.com

Abstract

The mining industry is one of the sectors with a high risk of occupational accidents due to the use of heavy equipment, unstable road conditions, and extreme working environments. This study employed a literature review method by examining three published journals that discussed the application of the HIRADC method (Hazard Identification, Risk Assessment, and Determining Control) in mining activities. The objective of this research is to analyze hazards and risks using the HIRADC method, which includes hazard identification, risk assessment, and risk control in mining areas. The purpose of this method is to reduce occupational accident risks in mining areas. A systematic review approach was used to examine relevant articles on occupational safety in the mining sector, with a particular focus on the implementation of the HIRADC method. Three studies were identified and then screened based on their titles, abstracts, and relevant content. The findings show that the most frequently identified hazards were physical hazards such as noise, vibration, dust, slippery roads, equipment collisions, and fall risks from height, along with chemical, biological, and ergonomic/unsafe act hazards. Risk assessments indicated that medium- and high-risk categories were the most dominant due to the relatively high probability of occurrence and severe impacts on both workers and equipment. Risk controls were mostly implemented through administrative measures and the use of personal protective equipment (PPE), while elimination and substitution were rarely applied, although some studies have started to move toward these strategies. Overall, the review emphasizes the importance of a comprehensive application of the hierarchy of controls to reduce occupational accident rates in mining areas.

Keywords: Industry, Mining, Accidents, Control, Risk.

Introduction

Occupational safety is a condition in which people are safe and protected from suffering, damage, and losses while working, whether in the use of tools, materials, machines, or processing operations, as well as during storage, and in maintaining and securing the work environment and workplace (Apria Perdana et al., 2021). The mining industry is one of the occupational fields well-known for its high potential and risk of accidents. This may be caused by unsafe acts or unsafe conditions, which can lead to accidents that are detrimental to both workers and companies (I.Y. Safitri, 2021 in Fadhilah et al., 2023).

For a long time, mining has been considered one of the most high-risk sectors worldwide (Mitchell et al., 1998 in Markus & Djunaidi, 2024). Many researchers have often faced difficulties in identifying the factors that cause

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accidents, with the hope of preventing similar mining accidents from occurring again in the future. The accident rate in the Australian mining industry is higher compared to other sectors (Hull et al., 1996 in Markus & Djunaidi, 2024). According to Iqbal & Kamaruddin (2021), some of the main causes of occupational accidents are education level (100%), years of service (67.67%), length of working hours (47%), OHS knowledge (77.78%), and unsafe behavior related to not using personal protective equipment (PPE) (55.56%).

According to Tubis et al. (2020), the mining process poses many risks related to operations and the resources used, including the interaction between the mining system and the environment. This process is considered highly intensive as it produces on a very large scale. The rate of occupational accidents continues to increase every year; therefore, efforts are needed to reduce and prevent occupational accidents and occupational diseases (ODs). Consistent implementation of occupational health and safety regulations in all areas of activity, especially during the production process in the mining sector, is strongly required (Fadhilah et al., 2023).

In the field of occupational health and safety, one method that is often used and considered quite effective in reducing workplace accidents is the HIRADC method (Hazard Identification, Risk Assessment, and Determining Control). HIRADC is an essential component of the Occupational Health and Safety Management System (OHSMS) because it relates to risk control efforts and aims to improve a company's OHS performance (Saputro & Lombardo, 2021). The HIRADC method is also an important component in creating a safe and comfortable work environment. As part of the OHSMS, risk assessment and control consist of hazard identification, risk assessment, and risk control activities (Ameiliawati, 2022).

Methods

The method used in this paper is a systematic review approach of relevant articles on occupational safety in the mining sector, particularly the application of the HIRADC method (Hazard Identification, Risk Assessment, and Determining Control). The research data were obtained using the keywords *"Industry, Mining, Accidents, Control, Risk"*. A total of three studies were found, which were then screened based on their titles, abstracts, and content relevant to this research. The literature data used in this review were sourced from national journals published and accessible through the Google Scholar search engine. The purpose of this study is to analyze hazards and risks using the HIRADC method, which includes hazard identification, risk assessment, and risk control, in order to prevent occupational accidents in mining areas.

Results

From the list of selected articles, an analysis was carried out from the aspect of hazard identification, which is then presented (Table 1):

Table 1. Results of Risk Identification Analysis in the Mining Industry in Indonesia

Paper Identity	Chemical	Physical	Biological	Ergonomic / Unsafe Act
Rio Apria Perdana et al. (2021)	-	√	√	√

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Paper Identity	Chemical	Physical	Biological	Ergonomic / Unsafe Act
Markus & Djunaidi (2024)	√	√	-	√
Fadhilah et al. (2023)	√	√	√	√

From the list of selected articles, an analysis was then carried out from the aspect of risk assessment, which is presented (Table 2):

Table 2. Results of Risk Assessment Analysis in the Mining Industry in Indonesia

Paper Identity	Very High	High	Medium	Low
Rio Apria Perdana et al., 2021	√	√	√	√
Markus & Djunaidi, 2024	√	√	√	-
Fadhilah et al., 2023	√	√	√	√

From the list of selected articles, an analysis was then carried out from the aspect of hazard control, which is presented (Table 3):

Table 3. Results of Hazard Control Analysis in the Mining Industry in Indonesia

Paper Identity	Elimination	Substitution	Engineering Control	Administrative Control	PPE
Rio Apria Perdana et al. (2021)	-	-	√	√	√
Markus & Djunaidi (2024)	√	√	√	√	√
Fadhilah et al. (2023)	√	√	√	√	√

Discussion

Hazard Identification

In industrial risk management, risk identification is a crucial component for preventing and controlling workplace incidents and occupational diseases (Kusumastuti et al., 2024). According to occupational health and safety theory, hazards can be categorized into several groups: chemical, physical, biological, and ergonomic/unsafe acts. Based on the observations from the three reviewed journals, it can be seen that the most frequently identified hazards in the mining industry are physical hazards. This is due to mining activities that inevitably involve machinery, which is often the main source of noise, vibration, and dust. As a result, the risks are greater and easier to detect compared to chemical or biological hazards. In the study conducted by Rio Apria Perdana et al. (2021), physical hazards included slippery

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roads, dusty roads, equipment collisions, and the risk of falling from cliffs. In addition, biological hazards such as snakes were identified, as well as unsafe acts such as drowsiness while working and failure to use seat belts.

The study by Markus & Djunaidi (2024) shows the dominance of physical hazards such as high-voltage electricity, moving machinery, dust, smoke, and noise. Chemical hazards were also identified, including toxic gases and heat energy. From an ergonomic perspective, risks such as manual handling, the use of hand tools, and locomotive operation were also observed. Meanwhile, Fadhilah et al. (2023) recorded the most comprehensive range of hazards: chemical (hazardous and flammable materials), physical (vibration, noise, extreme temperatures, working at height), biological (viruses, bacteria, fungi, insects, snakes), and ergonomic (non-neutral postures, failure to use PPE, work-related stress). This indicates that mining operations involve a wide spectrum of hazards.

Risk Assessment

Once all risks have been identified, control measures can be applied to eliminate or reduce these hazards. According to Landquist (2010), risk assessment is necessary to support decision-making and remedial actions so that resources can be utilized more efficiently (Marbun R. J. et al., 2019). Based on the three reviewed journals, the results show that the most dominant risk categories are high and medium. These categories are prevalent because most hazards occurring in mining operations have a relatively high frequency, such as slippery roads, dust, and vibration, with potentially serious consequences such as severe injuries, equipment damage, and even fatalities. In the study by Rio Apria Perdana et al. (2021), risks categorized as *very high* included operating units near cliffs and vehicles at high speed. *High* risks included miscommunication over radio, slippery roads, and queuing units. *Medium* risks consisted of units operating too closely or workers not wearing safety belts, while *low* risks included muddy work areas or the presence of snakes.

According to the study by Markus & Djunaidi (2024), *very high* risk was associated with heat energy from welding activities. *High* risks were identified in electrical energy, working at height, moving machinery, and locomotive operation. *Medium* risks included the use of hand tools and exposure to dust. Meanwhile, in the study by Fadhilah et al. (2023), the risk distribution was presented in percentages: 67% low, 27% medium, and 6% high. This indicates that most hazards can be controlled; however, there are still high-level risks that require special attention.

Risk Control

Risk control refers to the elimination or reduction of hazards so that they do not pose risks to employees (Kristin Mei Nora Aruan & Moses Laksono Singgih, 2021). All three reviewed journals refer to the hierarchy of controls: elimination, substitution, engineering controls, administrative controls, and the use of personal protective equipment (PPE). In the study by Rio Apria Perdana et al. (2021), administrative controls included the implementation of standard operating procedures (SOPs) and radio communication, while engineering controls involved improving mining roads, constructing embankments, and the use of safety belts. However, elimination and substitution techniques were not widely applied. Markus and Djunaidi (2024) found broader applications of risk control. These included elimination measures such as removing flammable materials from welding areas, substitution by using safer tools, engineering controls such as ventilation and lockout–tagout (LOTO) systems, and administrative controls through hot work permits

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and job safety analysis (JSA). The use of PPE such as helmets, respirators, and gloves was also strictly required for workers.

Fadhilah et al. (2023) identified hazard controls across all levels of the hierarchy. Some efforts included isolating hazardous areas, substituting chemicals with safer materials, applying engineering controls such as installing signage and ventilation, and using PPE such as helmets, earplugs, and protective shoes.Overall, the three journals demonstrate that physical hazards remain dominant, and the most frequently identified risks are at the medium and high levels. Administrative measures and PPE are the most commonly applied control methods, although some studies have begun to optimize elimination and substitution approaches.

Conclusion

Since mining activities involve heavy equipment, machinery, unstable road conditions, and extreme environments, it can be concluded that physical hazards are the most frequently identified in mining areas. As most hazards tend to occur relatively often and may have serious impacts, the risk levels most commonly identified are medium and high. Elimination and substitution are still rarely applied as control measures, while administrative controls and the use of personal protective equipment (PPE) remain the most widely implemented strategies. However, in some studies, substitution has been introduced as a more effective control effort. Therefore, to reduce the risk of occupational accidents in the mining sector, the comprehensive implementation of the hierarchy of controls is essential.

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