

INDUSTRY SUMMARY REPORT SERIES - 2024

THE PARADOXICAL EFFECTS OF EMERGING MINING TECHNOLOGIES

Mental Awareness, Respect and Safety
(MARS) Centre Research Report



Summary

The global mining sector faces complex risks that undermine safety, health, and workplace culture. Advanced digital technologies can mitigate these dangers and enhance worker experiences, but they may also worsen existing risks or create new ones. Consequently, the overall impact of emerging technologies on health, safety, and psychosocial risks in mining remains unclear.

The aim of this systematic review was to consolidate different perspectives on the impact of mining technologies. This review examined key technology categories and major themes related to implementation impacts, while also identifying key workplace changes.

The true value of technological advancements hinges on effectively managing and implementing workplace changes. Adopting human-centred principles and regularly evaluating practices allows organisations to design workplaces where technology enhances workers' well-being rather than detracting from it.

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Research Background

The International Labour Organization (ILO) identifies mining as one of the world's most hazardous industries, with high rates of injuries and disasters¹. Workers face numerous risks that harm their physical and mental health, weaken safety culture, reduce safety performance, and increase accidents. These risks include physical hazards such as dust exposure, high temperatures, noise and vibration, and heavy metals. Additionally, workers often face challenges related to distance and isolation from their families, as well as the high demands associated with shift work schedules, and other psychosocial risk factors such as workplace bullying, harassment, and occupational violence^{2,3}.

While emerging technologies and digital innovations have significant potential to improve health and safety in mining, they can also disrupt the workplace by exacerbating existing risks or introducing new ones. This systematic review aims to explore how emerging mining technologies affect health, safety, and psychosocial factors at work, as well as the mechanisms behind these impacts.

Methodology

A systematic literature review was conducted to compile and analyse existing research on how emerging technologies impact health and safety in the mining industry, focusing on both physical and psychosocial risks. This review followed the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) protocol⁴ and was carried out in three main phases:

- (1) selecting relevant research papers;
- (2) performing a descriptive analysis; and
- (3) conducting a thematic analysis.

Initial searches were conducted using Web of Science (WOS) and Scopus databases, as these platforms cover major online databases and offer a broad basis across diverse fields. The literature search used key terms focused on three main areas: Technologies, Health and Safety, and the Mining Industry.

In the screening stage, four selection criteria were applied:

- (1) only peer-reviewed journal articles were retained for further analysis to ensure the quality of the sources;
- (2) only articles with a focus on the implementation of technologies within the scope of the mining industry were retained;
- (3) only articles that mentioned health and safety outcomes from the implementations of technologies were included; and
- (4) articles published in the past ten years from 2014 to 2024.

From this search, 61 articles were selected for further descriptive and thematic analyses.

Results

Six categories of mining technology were identified in this review. These are: analytics artificial intelligence (AI) and machine learning (ML);

- augmented and virtual reality (AR/VR), digital twins;
- autonomous equipment;
- integrated remote operation centres;
- robotics; and
- smart sensors.

The review also explored how these technologies transform work by changing how, what, when, where, and by whom tasks are performed. These fundamental shifts were identified as key mechanisms explaining the paradoxical outcomes of emerging technologies in mining.

Overall, this literature review highlights the complex scenario where positive and negative effects on workplace health, safety, and psychosocial factors coexist following the implementation of mining technologies. It emphasises that technological changes are inherently neutral; their benefits or risks depend on how they are managed and integrated into the workplace.

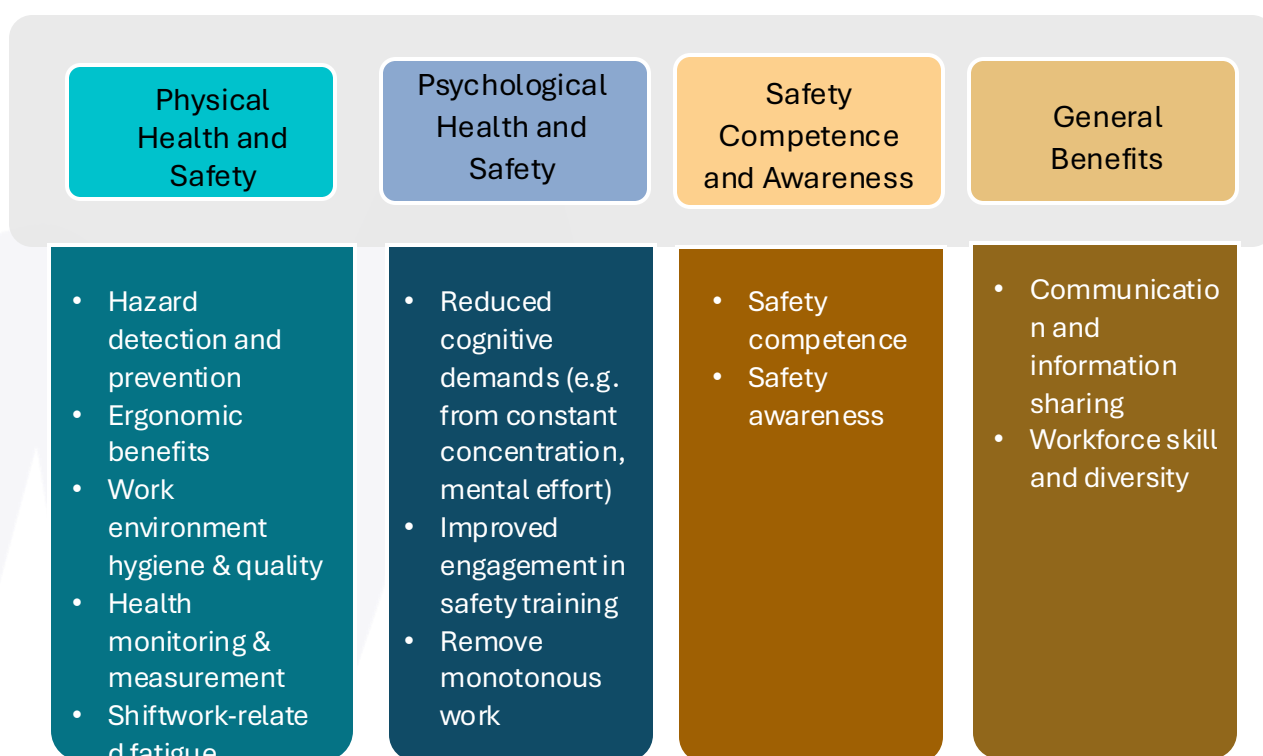


Figure 1. Health, Safety and Psychosocial Benefits

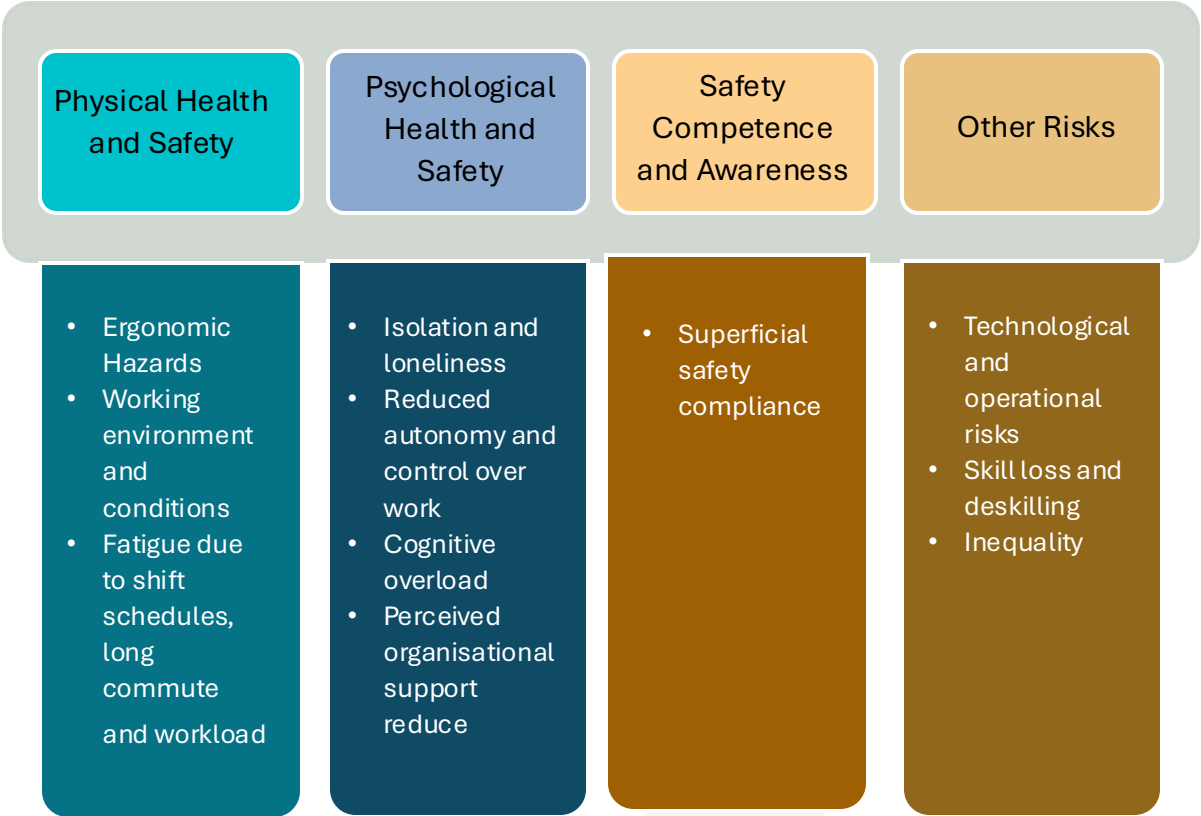


Figure 2. Health, Safety and Psychosocial Risks

Implications for Industry

This perspective on managing technology-induced changes offers valuable insights for the future of work and sustainable workplace design, aiming to create healthier, safer, and more sustainable environments. It aligns with the United Nations' Sustainable Development Goals (SDG) to improve working environments and promote decent work for all⁵.

Effective management of technological changes in the mining industry is crucial for fostering a sustainable and worker-friendly future. Strategic planning should include comprehensive training and reskilling initiatives to bridge skills gaps and support workforce adaptability, enabling smooth transitions to new roles.

Integration efforts must follow human-centred principles, ensuring that technologies are designed with workers' experience and safety in mind by involving them in design and feedback processes, thereby fostering ownership and acceptance of new tools. Additionally, continuous evaluation and feedback mechanisms are essential to ensure technology aligns with human factors over time.

This review provides practical implications for practitioners, decision-makers, and policymakers involved in digital innovations and the future of work in mining, guiding strategies and policies to promote safer, healthier, and more efficient workplaces.

A full technical report from this study will be available on the MARS Centre website in due course.



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