

Analysis of Occupational Health and Safety Programs to Reduce Workplace Accidents in Nickel Mining Areas

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Abstract

This study was motivated by the high-risk nature of mining operations and the need to ensure worker safety at PT Vale Indonesia Tbk's nickel mining site in Sorowako. The objective was to assess the implementation and effectiveness of its Occupational Health and Safety (OHS) program, particularly in preventing workplace accidents. A qualitative phenomenological approach was employed, involving in-depth interviews with six key informants. The findings indicate that the OHS program has contributed to a notable decline in minor accidents between 2022 and 2023, largely due to safety education, consistent enforcement of procedures, and regular safety communication. Nevertheless, challenges remain – such as uneven implementation, limited employee engagement, and the prevalence of unsafe behaviors, which account for the majority of incidents. The study concludes that achieving a truly effective safety culture requires moving beyond compliance toward shared responsibility, supported by strong leadership, active workforce participation, and the adoption of innovative tools and global best practices to realize the company's zero-harm vision. Practically, these findings offer an evidence-based roadmap for strengthening OHS systems in dynamic nickel mining environments; theoretically, this study enriches phenomenological discourse on the interplay between safety policies, human behavior, and technology within extractive industries in Indonesia.

Keywords: occupational health and safety (OHS), work-related accidents, nickel mining, safety culture, PT Vale Indonesia Tbk, phenomenology.

Introduction

The mining industry particularly nickel mining is inherently high-risk due to complex operations, harsh environments, and the interplay of human labor, heavy machinery, and chemical processes. In Indonesia, PT Vale Indonesia Tbk in Sorowako, South Sulawesi, stands as one of the nation's largest nickel producers and has implemented a comprehensive Occupational Health and Safety Management System (OHSMS). Despite this, workplace accidents persist, with unsafe acts contributing to 76.07% of incidents far outweighing unsafe conditions (23.93%) (Wimar Muhammad, 2025). Root causes are predominantly human factors, including SOP violations, inconsistent use of personal protective equipment (PPE), and fatigue, compounded by inconsistent field implementation and low worker engagement.

While prior studies in mining OHS have examined safety management systems (e.g., Hussein & Sarjono, 2025a; Atthobarani et al., 2024), most focus on compliance, structural controls, or macro-level safety performance often in coal or gold mining contexts. Few investigate nickel mining specifically, and even fewer integrate frontline worker perceptions with technology adoption and behavioral safety in the Indonesian setting. Moreover, existing literature tends to treat human error as a residual category rather than analyzing its systemic drivers within daily operations. This reveals a critical research gap: a lack of qualitative, context-sensitive studies that holistically examine how safety culture, regulatory adherence, and emerging technologies interact to influence accident causation and prevention in high-volume nickel operations.

This study addresses that gap by employing a qualitative phenomenological approach to capture the lived experiences and insights of six key OHS stakeholders at PT Vale. By centering on human behavior within a technologically advanced yet culturally complex mining operation, this research offers novel contributions: (1) empirical evidence from Indonesia's flagship nickel producer—a sector critical to the global energy transition; (2) a nuanced understanding of why unsafe acts dominate despite robust systems; and (3) actionable recommendations that bridge behavioral safety, digital innovation (e.g., IoT, VR/AR), and non-punitive reporting. In doing so, it advances beyond conventional OHS studies by integrating human factors, local operational realities, and next-generation safety tools providing a model for sustainable safety transformation in emerging mining economies.

Research Methods

This study employed a qualitative approach with a phenomenological method to gain an in-depth understanding of the experiences, perceptions, and meanings constructed by field actors regarding the implementation of the Occupational Health and Safety (OHS) program at PT Vale Indonesia Tbk. This approach was chosen to reveal the subjective realities of key informants directly involved in OHS management. The research was conducted at the Occupational Safety and Health (OSH) Department of PT Vale Indonesia Tbk, located at the Main Office Plant Site in Sorowako, Luwu Timur Regency, South Sulawesi, from January to April 2024. Data were collected from both primary and secondary sources. Primary data were obtained through semi-structured in-depth interviews with six key informants (N1–N6), including OHS managers, field supervisors, and mining operators. Secondary data were gathered from internal company documents, incident reports, OHS audit results, standard operating procedures (SOPs), and qualitative analysis data from the NVivo software. Data collection techniques included interviews, participatory observation in operational areas to assess SOP implementation, personal protective equipment (PPE) usage, and safety communication, as well as document review related to OHS policies and accident reports from 2022 to 2023. Data analysis was carried out using thematic analysis supported by NVivo software to assist in data reduction, coding, theme identification, and conclusion drawing. The process followed several stages: data transcription, initial coding, grouping codes into themes, meaning interpretation, and conclusion formulation. To ensure data credibility, source triangulation combining data from interviews, observations, and documents—was applied, along with member checking, where preliminary findings were returned to participants for validation to confirm accuracy and reliability.

Results and Discussion

Results

The implementation of the Occupational Health and Safety Management System (OHSMS) at PT Vale Indonesia Tbk has demonstrated a positive impact, particularly in reducing the number of minor workplace accidents during the 2022–2023 period. Key efforts include hazard identification using methods such as Job Safety Analysis (JSA), Hazard Identification, Risk Assessment, and Risk Control (HIRARC), and Hazard and Operability Study (HAZOP); the implementation of Daily Pre-Operation Inspection (P2H); Standard Operating Procedure (SOP) socialization; and consistent use of Personal Protective Equipment (PPE). Safety communication is conducted intensively through daily safety talks, placement of educational posters in

strategic locations, and screening of educational videos in dormitories and rest areas, as reported by informant N3.

Despite the structured system, challenges persist in the consistency of field implementation, particularly regarding SOP violations and inconsistent PPE usage. Interview results reveal that 76.07% of workplace accidents are caused by unsafe acts, while unsafe conditions account for only 23.93%, indicating that human factors are the primary root cause. Informant N5 recounted witnessing an accident directly caused by failure to use PPE, while N6 emphasized the importance of not skipping safety talks, highlighting that individual awareness and discipline are critical to the success of OHS programs.

Table 1. The study proposes the following matrix of key findings versus recommended solutions

Key Finding	Recommended Solution
76.07% of accidents caused by unsafe acts (e.g., PPE non-use, SOP violations, fatigue)	Implement a non-punitive near-miss reporting system to encourage transparency; introduce behavioral safety observation programs with peer feedback
Inconsistent field implementation of SOPs and PPE protocols	Strengthen supervisor accountability through KPI-linked safety audits; use digital checklists on mobile OHS apps to ensure compliance verification
Low active employee participation in safety initiatives	Co-create safety campaigns with frontline workers; establish safety champion networks to foster ownership
Reliance on reactive safety communication	Scale immersive VR/AR-based training simulating real mine hazards (e.g., equipment entrapment, gas exposure) to build situational awareness
Technology underutilized for behavioral insights	Integrate IoT data (e.g., PPE sensor logs, fatigue monitoring via wearables) with NVivo-coded incident narratives for holistic risk profiling
Safety culture driven by compliance rather than responsibility	Institutionalize Vale's Life-Saving Rules and Critical Risk Management (CRM) framework with leadership-led safety walks and visible commitment

Source: Processed Data, 2025

Furthermore, the company has adopted advanced technologies to support OHS management. The Internet of Things (IoT) is used for real-time monitoring of potential hazards such as landslides and gas leaks, while qualitative data analysis software (NVivo) is utilized to process incident reports and identify risk patterns. According to N6, these technologies serve not only as recording tools but also as data-driven decision-making instruments that enhance responsiveness and accuracy in risk management.

Discussion

The findings indicate that PT Vale Indonesia Tbk's OHSMS has been effective in creating a safer working environment, especially through systematic hazard identification, consistent communication, and technological integration. The significant reduction in minor accidents reflects improved safety awareness and procedural compliance among workers. The multi-channel communication strategy – ranging from daily safety talks to visual and digital media – ensures that safety messages reach all levels of personnel, including contractors and field operators, thereby fostering a more inclusive safety culture.

However, the predominance of unsafe acts (76.07%) over unsafe conditions (23.93%) underscores a critical challenge: human behavior remains the most unpredictable and influential factor in workplace safety. This aligns with established safety theories, which posit that accidents are rarely caused by a single factor but rather by the interaction of human, technical, and organizational elements. The experiences shared by informants N5 and N6 emphasize that even with robust systems in place, individual discipline and commitment to safety protocols are essential for effectiveness.

Regulations in OHS do not merely serve as formal rules but act as tools to shape discipline and cultivate a safety culture. The company's approach—combining enforcement with positive reinforcement, such as recognition for SOP compliance (N2)—proves more effective than punitive measures alone. This approach fosters a supportive work environment and encourages positive social norms around safety. Additionally, contractor management is prioritized through mandatory briefings, training, and regular inspections, ensuring that external workers adhere to the same OHS standards as permanent employees.

Table 2. Available internal safety records (2021–2023) show a clear downward trend in minor accidents following the intensification of OHS measures in 2022

Year	Total Minor Accidents	Notable OHS Intervention
2021	42	Baseline: Standard OHSMS in place; limited use of digital tools; safety talks inconsistently held
2022	24	Rollout of mandatory daily safety talks, P2H enforcement, IoT pilot for landslide monitoring
2023	13	Full integration of IoT hazard alerts, VR-based safety refreshers, NVivo-driven incident analysis, and reinforced SOP audits

Source: Processed Data, 2025

This represents a 69% reduction in minor accidents from 2021 to 2023, suggesting that the combined effect of behavioral reinforcement, procedural discipline, and technology adoption has significantly improved frontline safety performance.

Table 3. Summary Table: Root Causes of Accidents and Mitigation Measures

Root Cause Category	Specific Causes	Current Mitigation Measures	Proposed Enhancements
Unsafe Acts (76.07%)	- Failure to wear PPE - SOP violations - Fatigue/complacency	- Mandatory PPE policy - Daily safety talks - P2H checks	- Wearable PPE compliance sensors - Non-punitive near-miss reporting - Fatigue monitoring via biometric wearables
Unsafe Conditions (23.93%)	- Equipment malfunction - Unstable terrain - Poor ventilation	- HIRARC/HAZOP reviews - IoT-based landslide/gas monitoring - Routine maintenance	- Predictive maintenance using AI - Real-time environmental dashboards - Automated shutdown protocols for high-risk zones
Systemic Gaps	- Inconsistent SOP enforcement - Low worker	- SOP socialization - Safety posters & videos	- Digital SOP checklists on mobile apps - Worker-led safety committees

engagement

• Incentives for safety participation

Source: Processed Data, 2025

Together, the trend analysis and cause-mitigation table provide a clear evidence base: while structural and technological interventions have driven measurable progress, sustaining long-term safety gains requires deeper behavioral engagement and smarter integration of human-centered solutions with digital innovation. This dual focus is essential for PT Vale to advance toward its zero-harm vision.

The integration of technology, such as IoT and NVivo, represents an innovative shift toward proactive and data-driven OHS management. These tools enable early detection of hazards and support deeper analysis of incident trends. However, technology adoption faces barriers related to perceived usefulness and ease of use (Technology Acceptance Model), as some workers perceive digital tools as irrelevant or burdensome. This highlights the need for continuous training and change management to ensure effective technology adoption.

The holistic integration of knowledge enhancement, PPE availability, and effective supervision has proven crucial in shaping safe worker behavior, a finding supported by Amiroh & Suryanto (2025) and Atthobarani et al. (2024). Moving forward, integrating artificial intelligence (AI) and machine learning could transform OHS from a reactive to a predictive system by analyzing behavioral and environmental patterns. This study confirms that a strategic combination of integrated communication, technological innovation, and cultural reinforcement is essential for building a strong safety culture and significantly reducing workplace accidents.

Conclusions and Suggestions

Based on the research findings, the OHS program at PT Vale Indonesia Tbk has effectively reduced workplace accidents through consistent SOP enforcement, diverse safety communication, and recognition of safe behaviors; however, human factors—particularly unsafe acts accounting for 76.07% of incidents driven by PPE non-compliance, SOP neglect, and low safety awareness—remain the core challenge. To address this, concrete recommendations include implementing immersive, context-specific training such as quarterly VR/AR simulations for high-risk tasks, micro-learning safety modules via a mobile OHS app, and peer-led “Safety Mentor” programs, alongside cultural initiatives like co-created “Safety Ownership Charters,” monthly worker-led safety forums, non-financial incentives (e.g., recognition badges, priority scheduling), and gamified digital reporting linked to real-time IoT and NVivo-driven risk dashboards. While technology like IoT and analytics has enhanced hazard detection, its impact depends on regular, engaging training and worker buy-in. Looking ahead, this study opens opportunities for future research across other mining sectors such as comparing behavioral safety dynamics in coal, gold, or tin mining; evaluating digital OHS tools in small-scale operations; exploring community and family influences on miner behavior; assessing cross-cultural safety leadership in multinational mining contexts; and studying the long-term effects of non-punitive reporting systems in high-risk industries beyond mining. By integrating these targeted training, cultural, and technological strategies, PT Vale can advance toward its zero-harm vision while contributing actionable insights to global occupational safety practice.

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