

## Emergency response preparedness in a mining contractor operation in Southeast Sulawesi, Indonesia: An ISRS based quantitative case study

Kesiapsiagaan tanggap darurat dalam operasi kontraktor pertambangan di Sulawesi Tenggara, Indonesia: Studi kasus kuantitatif berbasis ISRS

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### Abstract

Mining operations involve multiple hazards that can generate complex emergencies, yet component-level evidence distinguishing internal preparedness from preparedness beyond company operational boundaries remains limited, particularly among Indonesian mining contractors, making this study novel in identifying boundary-specific Emergency Response Preparedness (ERP) gaps. This study assessed ERP at Abadi Site MLP Ltd., North Konawe, Southeast Sulawesi, and identified component-specific preparedness deficiencies. A descriptive quantitative single-site case study was conducted using the International Safety Rating System (ISRS) Emergency Preparedness framework across 13 elements, supported by checklist assessment, document review, structured observation, and semi-structured interviews with three purposively selected informants. Eleven elements were applicable, while two were classified as not applicable, resulting in an applicable maximum score of 645 from a theoretical 765 points. The site achieved 558 points, corresponding to 86.5% fulfillment. Seven applicable elements achieved 100% fulfillment, while Emergency State Plan, First Aid in Accidents, and Protection and Rescue System reached 98.6%, 93.8%, and 86.7%, respectively. The largest gap was Outdoor Emergencies Company, which scored 0%, revealing strong internal preparedness but inadequate documented external emergency arrangements. These findings support strengthening coordination with contractors, transportation providers, external responders, and mutual-aid partners, consistent with occupational health priorities and the Islamic principle of *hifz al-nafs* in protecting life and preventing avoidable harm.

### Abstrak

Operasi pertambangan melibatkan berbagai bahaya yang dapat menimbulkan keadaan darurat yang kompleks, namun bukti berbasis komponen yang membedakan kesiapsiagaan internal dengan kesiapsiagaan di luar batas operasional perusahaan masih terbatas, khususnya pada kontraktor pertambangan di Indonesia. Oleh karena itu, penelitian ini menawarkan kebaruan dengan mengidentifikasi kesenjangan spesifik pada batas kesiapsiagaan tanggap darurat (*Emergency Response Preparedness/ERP*). Penelitian ini bertujuan menilai ERP di Abadi Site MLP Ltd., Konawe Utara, Sulawesi Tenggara, serta mengidentifikasi kesenjangan kesiapsiagaan pada setiap komponen. Penelitian menggunakan desain kuantitatif deskriptif dengan pendekatan studi kasus satu lokasi berdasarkan kerangka *International Safety Rating System (ISRS) Emergency Preparedness* yang mencakup 13 elemen, didukung oleh penilaian checklist, telaah dokumen, observasi terstruktur, dan wawancara semi-terstruktur dengan tiga informan yang dipilih secara purposif. Sebelas elemen dinyatakan berlaku, sedangkan dua elemen diklasifikasikan tidak berlaku, sehingga skor maksimum yang dapat dinilai adalah 645 dari skor teoritis 765. Lokasi penelitian memperoleh 558 poin atau tingkat pemenuhan 86,5%. Tujuh elemen mencapai pemenuhan 100%, sedangkan *Emergency State Plan*, *First Aid in Accidents*, dan *Protection and Rescue System* masing-masing mencapai 98,6%, 93,8%, dan 86,7%. Kesenjangan terbesar ditemukan pada elemen *Outdoor Emergencies Company* dengan skor 0%, yang menunjukkan kuatnya kesiapsiagaan internal namun belum memadainya dokumentasi kesiapsiagaan untuk keadaan darurat eksternal. Temuan ini mendukung penguatan koordinasi dengan kontraktor, penyedia transportasi, petugas tanggap darurat eksternal, dan mitra bantuan bersama, sejalan dengan prioritas kesehatan kerja dan prinsip Islam *hifz al-nafs* dalam melindungi jiwa serta mencegah bahaya yang dapat dihindari.

### Graphical Abstract



### Keyword

disaster planning; emergencies; first aid; mining sector; occupational health

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## INTRODUCTION

Mining is among the highest-risk industrial sectors because its operations involve complex processes, heavy equipment, hazardous materials, and geographically dispersed work areas. These conditions expose workers to multiple emergency scenarios, including fires, explosions, equipment-related incidents, structural failures, and hazardous material releases (Dursun, 2024; Zvarivadza et al., 2024). Occupational accidents in mining may result in fatalities, permanent or partial disability, absenteeism, and substantial losses of working days (Cruz-Ausejo et al., 2024). Occupational health and safety (OHS) therefore requires systematic hazard identification, risk assessment, and implementation of appropriate control measures to protect workers' health, safety, and well-being while maintaining safe and sustainable workplaces (Ahmed et al., 2023; Liu et al., 2023). Strengthening emergency preparedness in high-risk industries is also consistent with Sustainable Development Goal (SDG) 3 on health and well-being and SDG 8, particularly Target 8.8, which calls for safe and secure working environments for all workers.

Although comprehensive safety management can reduce occupational risks, preventive controls cannot eliminate all potential emergency events in mining operations (Shaikh et al., 2025). Multiple hazards may occur simultaneously or escalate rapidly, resulting in fires, explosions, hazardous material exposure, structural failures, or other critical incidents requiring immediate response (Diannita et al., 2026). Such events may demand coordinated rescue, medical assistance, communication, evacuation, and command functions. In Indonesia, Law Number 1 of 1970 on Occupational Safety provides the regulatory basis for protecting workers from workplace hazards. Emergency preparedness should therefore be integrated into routine occupational safety management as a proactive risk-control measure, particularly in high-risk workplaces.

A central occupational safety challenge is that the presence of emergency procedures does not necessarily indicate that an organization is operationally prepared to manage a major incident. Previous mining studies have largely focused on accident causation and preventive factors, including non-compliance with work procedures, inadequate use of personal protective equipment, and insufficient worker knowledge (Al-Bayati et al., 2023). While these factors are important for accident prevention, they provide limited evidence regarding the readiness of

emergency organizations, communication systems, response personnel, rescue resources, first aid arrangements, and coordination mechanisms. Therefore, a structured assessment is required to determine whether emergency preparedness systems are sufficiently developed, implemented, and supported to function effectively during critical events (Gooding et al., 2022).

Emergency Response Preparedness (ERP) encompasses organizational and operational capacities required to respond effectively when emergencies occur (Zang & Lee, 2024). Effective preparedness extends beyond written emergency plans and includes competent response personnel, emergency organization, communication systems, rescue capabilities, first aid, equipment and resource availability, coordination, leadership, and decision-making. The National Institute for Occupational Safety and Health emphasizes that mine emergency preparedness should incorporate planning, training, communication, leadership, and decision-making to support effective emergency response (NIOSH, 2010) (Raza et al., 2026). These components are particularly important in mining operations, where emergencies may develop rapidly and require coordinated actions across multiple teams and locations.

(Recent developments in Indonesia's mining and mineral-processing sectors have increased the complexity of occupational and process-safety risks, particularly in operations involving high-temperature processes, hazardous materials, heavy equipment, and interconnected contractor activities. Such environments require emergency preparedness systems that are not limited to incident response procedures, but are supported by integrated arrangements for rescue, emergency medical services, communication, evacuation, command and coordination, and access to specialized external resources (Hancko et al., 2025). For mining contractors operating within large and complex industrial settings, preparedness should therefore be developed as a coordinated system that links internal response capacity with host-company emergency structures and relevant external emergency services. The effectiveness of these arrangements depends on clearly defined responsibilities, resource availability, communication protocols, response-time expectations, interoperability, and periodic testing through drills and exercises (Xiong et al., 2023; Howe et al., 2023).

The International Safety Rating System (ISRS) provides a structured framework for evaluating safety management performance, including emergency

preparedness. The ISRS Emergency Preparedness framework enables organizations to assess multiple preparedness components systematically and generate component-level and overall compliance scores. Previous research has demonstrated the usefulness of ISRS-based assessment for evaluating emergency response preparedness through structured component scoring (Owusu et al., 2025; Joshi et al., 2024; Wang et al., 2026; Imron & Choiruddin, 2025). However, available occupational safety research still provides limited quantitative evidence on the extent to which emergency preparedness is implemented comprehensively across multiple components, particularly in mining contractor operations. This limitation reduces the ability of organizations to identify which preparedness elements are well established and which require priority improvement.

Empirical application of quantitative ISRS-based ERP assessment remains limited in Indonesian mining contractor settings, particularly in Southeast Sulawesi, where mining operations are conducted within complex environments requiring coordination between internal emergency teams and external resources. The present study addresses this gap through a descriptive quantitative single-site case study at Abadi Site MLP Ltd., North Konawe Regency, Southeast Sulawesi. Using the ISRS Emergency Preparedness framework, the study evaluates preparedness across 13 applicable elements based on checklist assessment, document review, structured observation, and semi-structured interviews with three purposively selected informants. The novelty of this study lies in providing a component-specific quantitative assessment of ERP within a mining contractor operation and identifying implementation gaps that can inform targeted safety improvements. Accordingly, this study aimed to quantitatively assess the level of Emergency Response Preparedness at Abadi Site MLP Ltd. using the ISRS framework and identify priority preparedness gaps requiring improvement.

## **METHODS**

### **Study Design**

This study employed a descriptive quantitative single-site case study design to assess Emergency Response Preparedness (ERP) at a mining contractor operation in Southeast Sulawesi, Indonesia. The assessment quantified ERP implementation using the Emergency Preparedness framework of the International Safety Rating System (ISRS).

Quantitative scoring was supported by document review, structured field observation, and semi-structured interviews to verify assessment evidence and provide organizational context. A single-site case study approach was considered appropriate because ERP was evaluated within its actual operational setting using multiple sources of evidence, thereby supporting triangulation and strengthening the validity of the assessment. The study was descriptive and was not designed to examine causal relationships between ERP implementation and occupational accident or injury outcomes.

### **Study Setting and Period**

The study was conducted from May to July 2026 at Abadi Site MLP Ltd., Lameruru, Langgikima District, North Konawe Regency, Southeast Sulawesi, Indonesia. The site operates within a mining environment characterized by complex operational activities, heavy equipment, hazardous materials, and potential emergency scenarios requiring coordinated response. The assessment focused on the ERP system implemented at the site during the study period.

### **Assessors and Key Informants**

The ISRS assessment involved seven assessors who had received competency-based training and certification relevant to emergency preparedness and response. Training undertaken by the central coordinator and Emergency Response Team (ERT) included working at heights, water incident rescue, fire rescue, basic firefighting, medical first response, underwater operations, and hazardous materials handling. The assessors had relevant experience in occupational safety and ISRS-based assessment and were responsible for reviewing applicable criteria and assigning scores based on verified evidence.

Emergency preparedness assessment activities were coordinated by the Safety, Health, and Environment (SHE) Department and involved relevant personnel, including the central coordinator, supervisors, and ERT members. Assessment decisions were based on documentary evidence and verified through observation and interviews where necessary. When differences arose among assessors, the evidence and applicable ISRS criteria were reviewed and discussed until consensus was reached before the final score was recorded. This process was intended to reduce assessor subjectivity and improve consistency in scoring.

Three key informants were purposively selected to provide contextual information and verify the assessment findings: a field worker from the Mining Operational Safety sector, the ERT Leader, and the Safety, Health, and Environment Group Leader (GL SHE). Informants were eligible if they had participated in emergency response training or simulations, were directly involved in ERP implementation or emergency response activities, possessed relevant knowledge of the site preparedness system, and were willing to participate.

### Data Collection

Data were collected from three complementary sources: the ISRS checklist and document review, structured field observation, and semi-structured interviews. The ISRS Emergency Preparedness checklist served as the primary quantitative assessment instrument. Organizational documents were reviewed to determine whether requirements specified in each applicable assessment item had been formally established and documented. Reviewed documents included emergency response plans, emergency organizational structures, training records, drill and exercise reports, communication procedures, emergency equipment records, first-aid and medical support documentation, and other relevant occupational safety records.

Structured field observations were conducted to verify whether arrangements identified through document review had been implemented in practice. Observations focused on the availability, accessibility, condition, and operational readiness of emergency equipment, protection systems, communication facilities, response resources, and relevant emergency procedures.

Semi-structured interviews with the three key informants were used to clarify organizational practices, verify interpretation of documentary and observational findings, and obtain contextual information when documentary evidence was incomplete or required further explanation. Documentary evidence represented formal preparedness arrangements, observations verified their physical and operational implementation, and interviews provided contextual confirmation. The three evidence sources were compared throughout the assessment process to reduce reliance on a single source and strengthen evidence triangulation.

### Research instrument

The primary instrument was the ISRS Emergency Preparedness checklist based on the International Safety Rating System framework. The assessment covered 13 emergency preparedness sub-processes: (1) Emergency Needs Assessment, (2) Site Emergency Plan, (3) Off-Site Emergency Plan, (4) Crisis Plan, (5) Business Continuity Plan, (6) Emergency Communications, (7) Emergency Protection Systems, (8) Energy Controls, (9) Emergency Teams, (10) Drills and Exercises, (11) First Aid, (12) Medical Support, and (13) Organised Outside Help and Mutual Aid ([International Safety Rating System, 2005](#)).

The ISRS framework applies a structured scoring approach in which points are assigned to applicable criteria according to the extent to which required preparedness arrangements are documented and implemented. Previous Indonesian application of ISRS-based ERP assessment calculated preparedness as the proportion of achieved points relative to the maximum applicable score. In the present study, the maximum applicable score across the assessed ERP criteria was 645 points.

### ISRS assessment and scoring procedure

Each applicable assessment item was reviewed against the corresponding ISRS criteria. Documentary evidence was first examined to determine whether the required arrangement had been formally established. Implementation was subsequently verified through structured observation and, when necessary, interviews with relevant personnel. Evidence was considered adequate when documented requirements were supported by observable implementation and/or consistent information from knowledgeable personnel.

Scores were assigned according to the applicable ISRS criteria. Where evidence was incomplete, inconsistent, or could not be verified, scoring reflected the level of implementation demonstrable from the available evidence. Item-level scores were aggregated into component-specific scores and subsequently summed to produce the overall ERP score. The scoring structure and maximum applicable scores for each emergency preparedness component are presented in [Table 1](#).

### Data analysis

Quantitative ISRS data were analysed descriptively. Scores for individual assessment items were summed to obtain component-specific and overall

Table 1

ISRS emergency preparedness assessment and scoring framework

| No. | Emergency Preparedness Component      | Applicable Items (n) | Maximum Score |
|-----|---------------------------------------|----------------------|---------------|
| 1   | Emergency Needs Assessment            | 8                    | 40            |
| 2   | Site Emergency Plan                   | 12                   | 60            |
| 3   | Off-Site Emergency Plan               | 8                    | 40            |
| 4   | Crisis Plan                           | 8                    | 40            |
| 5   | Business Continuity Plan              | 8                    | 40            |
| 6   | Emergency Communications              | 10                   | 50            |
| 7   | Emergency Protection Systems          | 10                   | 50            |
| 8   | Energy Controls                       | 8                    | 40            |
| 9   | Emergency Teams                       | 10                   | 50            |
| 10  | Drills and Exercises                  | 10                   | 50            |
| 11  | First Aid                             | 8                    | 40            |
| 12  | Medical Support                       | 8                    | 45            |
| 13  | Organised Outside Help and Mutual Aid | 10                   | 100           |
|     | Total applicable assessment           | 118                  | 645           |
|     | Actual assessment score               | —                    | 558           |
|     | Overall fulfillment (%)               | —                    | 86.5          |

Note: Each applicable item was assigned a full, partial, or zero score according to the ISRS assessment criteria. Items classified as not applicable (N/A) were excluded from both the numerator and denominator. Assessment evidence was verified through document review, structured observation, and interviews. Overall fulfillment was calculated as: (obtained score / maximum applicable score) × 100 = (558 / 645) × 100 = 86.5%.

ERP scores. The overall ERP compliance level was calculated using the following [Formula 1](#).

$$ERP \text{ compliance } (\%) = \frac{\text{Observed score}}{\text{Maximum applicable score}} \times 100 \quad (1)$$

Component-specific compliance was calculated using the same formula by dividing the observed score for each component by its corresponding maximum applicable score and multiplying by 100. These percentages were used to compare preparedness across the 13 ISRS components and identify areas of relatively strong implementation and components requiring priority improvement.

Document review, structured observations, and interview findings were not assigned separate quantitative scores. Instead, they were used to verify and contextualize the ISRS assessment. Particular attention was given to discrepancies between formally documented arrangements and evidence of operational implementation. This approach enabled differentiation between the existence of preparedness procedures and their demonstrated readiness in practice.

### Quality assurance

Several procedures were applied to strengthen assessment reliability. First, the assessment used standardized ISRS criteria to guide scoring. Second, multiple sources of evidence were triangulated before final scores were assigned. Third, assessments were conducted by trained personnel with relevant

emergency response and occupational safety competencies. Fourth, scoring differences among assessors were resolved through evidence-based consensus. These procedures were intended to improve consistency, transparency, and reproducibility of the ERP assessment.

### Ethical considerations

The study complied with applicable institutional ethical requirements. Participation in semi-structured interviews was voluntary, and all informants received information regarding the study objectives, procedures, confidentiality safeguards, and their right to decline questions or withdraw without consequences. Informed consent was obtained before participation. No personally identifiable information was included in the analysis or reporting, and the study did not collect sensitive health information. Ethical approval was obtained from the relevant institutional authority under approval number 30/UNIDA/KIA-i/XI/1447.

## RESULTS

### Overall emergency response preparedness assessment

Emergency Response Preparedness (ERP) at Abadi Site MLP Ltd. was assessed using the International Safety Rating System (ISRS). The assessment comprised 13 emergency preparedness elements with a theoretical maximum score of 765

Table 2  
International Safety Rating System (ISRS) emergency preparedness assessment results

| ISRS element                   | Maximum score | Obtained score | Fulfillment (%) | Applicability |
|--------------------------------|---------------|----------------|-----------------|---------------|
| Administration                 | 35            | 35             | 100             | Applicable    |
| Emergency Condition Analysis   | 30            | 30             | 100             | Applicable    |
| Emergency State Plan           | 145           | 143            | 98.6            | Applicable    |
| Outdoor Emergencies Company    | 60            | 0              | 0               | Applicable    |
| Energy Source Control          | 25            | 25             | 100             | Applicable    |
| Protection and Rescue System   | 150           | 130            | 86.7            | Applicable    |
| Emergency Team                 | 50            | 50             | 100             | Applicable    |
| Assessment System              | 30            | 30             | 100             | Applicable    |
| First Aid in Accidents         | 80            | 75             | 93.8            | Applicable    |
| Organized Outside Help         | 60            | —              | —               | N/A           |
| Post-Event Plan                | 20            | 20             | 100             | Applicable    |
| Emergency Communication System | 20            | 20             | 100             | Applicable    |
| Communication with Community   | 60            | —              | —               | N/A           |
| Total applicable score         | 645           | 558            | 86.5            | —             |

Note: The theoretical maximum score across all 13 ISRS elements was 765 points. Organized Outside Help and Communication with Community were classified as not applicable (N/A), each contributing 60 points; therefore, 120 points were excluded from the denominator, resulting in an applicable maximum score of 645 points. N/A elements were not treated as zero fulfillment. In contrast, Outdoor Emergencies Company was applicable but received 0 of 60 points, indicating that the assessed requirements were not fulfilled. The overall ERP fulfillment level was calculated as  $(558/645) \times 100 = 86.5\%$ .

points. Two elements, Organized Outside Help and Communication with Community, were classified as not applicable (N/A), each with a maximum score of 60 points. Accordingly, the applicable maximum score was 645 points. The site obtained 558 points, corresponding to an overall ERP fulfillment level of 86.5%.

Seven applicable elements achieved full fulfillment (100%): Administration (35/35), Emergency Condition Analysis (30/30), Energy Source Control (25/25), Emergency Team (50/50), Assessment System (30/30), Post-Event Plan (20/20), and Emergency Communication System (20/20). High levels of fulfillment were also observed for the Emergency State Plan (143/145; 98.6%), First Aid in Accidents (75/80; 93.8%), and Protection and Rescue System (130/150; 86.7%) (see Table 2).

The largest preparedness gap was identified in the Outdoor Emergencies Company element, which received 0 of 60 points. This result indicates that an applicable requirement concerning emergencies outside the company's operational area was not fulfilled. In contrast, Organized Outside Help and Communication with Community were classified as N/A and excluded from the applicable maximum score. Thus, a zero score represented an applicable but unfulfilled requirement, whereas N/A indicated that the element was not applicable to the assessed site.

### Emergency state plan

The Emergency State Plan achieved 143 of 145 points (98.6%), indicating a high level of fulfillment. The site had documented emergency plans for several scenarios, including heavy-equipment incidents, explosions, fires, medical emergencies, and evacuation. Emergency reporting procedures were established and communicated to employees through safety induction. The reporting procedure required information on the reporter's identity, type and location of the incident, number and condition of casualties, and assistance required. Response arrangements were also established for ERT, ambulance, medical, and security personnel according to the type of emergency.

Emergency preparedness training and drills were conducted regularly, with approximately one to two exercises per month. Employees also received basic fire-response training, including the use of portable fire extinguishers. Procedures for hazardous materials covered identification, labeling, storage, spill and leak response, and communication of chemical hazards. The ERT was responsible for search and rescue activities and preparation of rescue equipment. Following emergency response activities, an all-clear and review process was conducted to evaluate the response and confirm the safety status of the affected area. Overall, the findings showed that the site had established comprehensive internal emergency

planning arrangements, although two points within this element remained unfulfilled.

#### **Outdoor emergencies company**

The Outdoor Emergencies Company element received 0 of 60 points, representing the largest gap identified in the ERP assessment. The site's existing ERP documentation did not adequately address emergencies occurring outside the company's operational area. Emergency response arrangements primarily focused on incidents occurring within the company premises, including hazardous-material incidents. Transportation and management of hazardous materials outside the operational area were undertaken by third parties; however, emergency arrangements for external transportation and other off-site activities were not adequately incorporated into the written ERP.

The assessment also identified the absence of a formal written reporting and coordination mechanism for external emergencies. Communication with external emergency organizations was conducted through informal channels when assistance was required. Therefore, formal arrangements involving the company, third-party contractors, transportation providers, external responders, and other relevant organizations were not sufficiently documented.

#### **Protection and rescue system**

The Protection and Rescue System achieved 130 of 150 points (86.7%). Available emergency protection and rescue resources included portable fire extinguishers, rescue equipment, emergency transportation, evacuation routes, and designated assembly areas. Active and passive fire protection measures were also implemented across buildings and operational units. The primary gap within this element concerned incomplete provisions for spill and leak control. Although substantial protection and rescue infrastructure was available, the assessment showed that hazardous-material spill and leak management required further strengthening. Fire protection arrangements were generally consistent with the technical requirements established under Minister of Public Works Regulation No. 26 of 2008 concerning fire protection systems in buildings and their environments.

#### **First aid in accidents**

The First Aid in Accidents element achieved 75 of 80 points (93.8%). The site had a medical clinic equipped with an emergency room and first-aid facilities, while medical personnel worked in shifts to

provide continuous emergency medical support. The main gap involved incomplete first-aid training coverage. Some supervisors had not participated in first-aid training. Thus, although medical facilities and trained medical personnel were available, first-aid competency had not yet been extended to all relevant supervisory personnel. Workplace first-aid arrangements were assessed in relation to Minister of Manpower Regulation No. 15 of 2008 concerning First Aid in Workplace Accidents.

#### **Emergency team**

The Emergency Team achieved full fulfillment (50/50; 100%). The site had established an ERT with defined responsibilities for emergency preparedness, response, search and rescue, and preparation of rescue equipment. Workers also participated in emergency response exercises and basic fire-response training. The 100% score indicates that all applicable ISRS requirements for this element were fulfilled at the time of assessment. However, the assessment evaluated compliance with the specified preparedness criteria rather than actual ERT performance during a real emergency.

#### **Emergency communication system**

The Emergency Communication System achieved full fulfillment (20/20; 100%). The site had designated communication channels for emergency response, and emergency contact information and reporting procedures were communicated to employees through safety induction and other internal communication mechanisms.

Emergency reports were required to include the identity of the reporter, incident location and type, affected persons, and assistance required. The assessment confirmed the availability and implementation of these communication arrangements. However, operational indicators such as response time, message accuracy, and communication effectiveness during actual emergency events were not independently measured.

#### **Organized outside help and communication with community**

Organized Outside Help and Communication with Community were classified as N/A. Each element had a theoretical maximum score of 60 points; therefore, 120 points were excluded from the applicable maximum score. Consequently, the theoretical maximum score of 765 points was reduced to an applicable maximum of 645 points.

The N/A classification differed from a score of zero. A zero score indicated that an applicable requirement had been assessed but was not fulfilled, as observed for the Outdoor Emergencies Company element. In contrast, N/A indicated that the requirement was not applicable to the assessed site under the ISRS assessment criteria. This classification was therefore excluded from both the numerator and denominator of the overall fulfillment calculation.

## DISCUSSION

### Overall ERP preparedness performance

The overall ISRS fulfillment score of 86.5% indicates that most applicable Emergency Response Preparedness (ERP) requirements at Abadi Site MLP Ltd. were fulfilled during the assessment period. Of the 11 applicable elements, seven achieved full fulfillment (100%), three showed high but incomplete fulfillment, and one received no points. Two additional elements were classified as not applicable (N/A) and excluded from the applicable maximum score. Although these findings indicate relatively strong preparedness, particularly for internally managed emergencies, the overall percentage should not be interpreted as evidence of complete operational readiness.

The most notable finding was the contrast between strong internal preparedness and the absence of documented arrangements for emergencies occurring outside the company's operational area. While the Emergency Team and Emergency Communication System achieved 100% fulfillment, the Outdoor Emergencies Company element received 0 of 60 points. This pattern indicates that preparedness was substantially more developed for emergencies occurring within the company's operational boundaries than for incidents requiring external coordination. The component-level ISRS assessment was therefore valuable in identifying specific weaknesses that could have been obscured by the relatively high overall fulfillment score.

Similar findings have been reported in high-risk industries. [Ahmad Naim et al. \(2022\)](#) showed that successful emergency exercises may coexist with unmet preparedness requirements, while [Pramayu et al. \(2025\)](#) identified multiple interconnected dimensions of emergency management capability in coal mining. These findings indicate that a high aggregate ISRS score should be interpreted alongside component-specific deficiencies rather than as a stand-alone measure of operational readiness.

### Internal preparedness and emergency planning

The Emergency State Plan achieved 98.6% fulfillment, demonstrating that the site had established comprehensive arrangements for foreseeable internal emergencies. These included emergency procedures, reporting mechanisms, Emergency Response Team (ERT) responsibilities, training and drills, hazardous-material procedures, and post-event review. This finding suggests that emergency preparedness had been incorporated into routine occupational safety management rather than treated solely as a reactive measure.

The finding is consistent with NIOSH guidance, which emphasizes planning, training, communication, leadership, and coordinated decision-making as essential components of mine emergency management ([NIOSH, 2010](#)). The ISRS framework similarly recognizes emergency needs assessment, emergency planning, communication systems, emergency teams, drills and exercises, first aid, medical support, and external assistance as interconnected components of effective preparedness. Nevertheless, the near-complete internal preparedness score should be interpreted together with the absence of documented external emergency arrangements. This contrast demonstrates that strong internal systems alone do not constitute comprehensive ERP, particularly in mining operations that depend on contractors, transportation providers, and external emergency resources.

Recent mining research supports this finding. [Onifade \(2021\)](#) emphasized that emergency preparedness requires integrated planning, training, hazard recognition, communication, and clear responsibilities, while [Xiong et al. \(2023\)](#) highlighted the need to align emergency capability with operational risks and strengthen both internal and external response capacity. Thus, strong internal planning should be complemented by capabilities extending beyond organizational boundaries.

### Protection and rescue capacity

The Protection and Rescue System achieved 86.7% fulfillment, indicating substantial implementation of physical and operational emergency protection measures. Fire extinguishers, rescue equipment, evacuation routes, assembly areas, and emergency transportation were available, demonstrating that essential emergency-response infrastructure had been established. The principal weakness within this component concerned spill and leak control. This gap is operationally important because hazardous-material

incidents may require rapid containment, isolation, appropriate personal protective equipment, communication, rescue, and environmental protection measures. The finding therefore indicates the need to strengthen the integration of hazardous-material management with emergency-response procedures. In addition to the availability of emergency equipment, periodic inspection, maintenance, accessibility checks, and practical exercises are necessary to ensure that such resources remain functional and can be used effectively during an emergency.

Recent mining research also highlights the importance of integrated emergency readiness. [Salami et al. \(2023\)](#) identified evacuation routes, protective equipment, emergency plans, and personnel preparedness as key determinants of safe evacuation, while [Wen et al. \(2024\)](#) emphasized the integration of monitoring, communication, coordination, and resource deployment. These findings indicate that emergency equipment and control systems must be not only available but also accessible and integrated into the overall response system.

#### **First aid and human competency**

The First Aid in Accidents component achieved 93.8% fulfilment, indicating that first-aid infrastructure and medical support were largely established. The availability of a medical clinic, emergency facilities, and medical personnel provides an important foundation for emergency medical response. However, incomplete first-aid training among some supervisors represented a specific gap in preparedness.

This finding highlights the distinction between the availability of resources and the competency of personnel. During an emergency, supervisors or other workers may be the first individuals present at the incident location before professional medical personnel arrive. Consequently, adequate first-aid coverage depends not only on clinical facilities but also on appropriately trained personnel distributed throughout the workplace. Extending first-aid training to all designated supervisors and other relevant personnel would therefore strengthen the human-resource component of ERP. In a cross-sectional study involving 741 underground mineworkers in Sweden, [Karlsson et al. \(2020\)](#) found that preparedness to provide an immediate response to injured colleagues was significantly associated with familiarity with rescue procedures and previous experience using self-protective and first-aid equipment. Workers familiar with emergency rescue procedures reported greater preparedness than those who were unfamiliar with

them, while experience with first-aid and protective equipment was also positively associated with preparedness.

#### **Emergency team and communication capacity**

The Emergency Team and Emergency Communication System each achieved 100% fulfilment, indicating that organizational responsibilities, internal communication arrangements, trained response personnel, and emergency procedures were well established. The presence of defined responsibilities, rescue resources, and regular exercises provides an organizational foundation for coordinated emergency response. This finding is consistent with mine emergency management principles emphasizing structured communication, trained personnel, and coordinated decision-making.

However, full fulfilment of the ISRS criteria should not be interpreted as evidence that response performance during an actual emergency would necessarily be optimal. The present study assessed the existence and implementation of specified preparedness requirements but did not independently test ERT response time, communication accuracy, decision-making, rescue effectiveness, or operational performance under real emergency conditions. Periodic simulations incorporating measurable indicators such as mobilization time, message accuracy, command effectiveness, rescue performance, and post-drill evaluation would provide stronger evidence of operational readiness.

Recent evidence suggests that emergency teams and communication systems should be supported by demonstrated coordination performance. [O'Brien et al. \(2020\)](#) emphasized the importance of information sharing and situational awareness, while [Waring et al. \(2020\)](#) identified coordination difficulties even when formal response structures were established. These findings support the use of performance-based exercises to assess communication and decision-making under emergency conditions.

#### **External emergency preparedness as the principal gap**

The most significant weakness identified in this study was the 0% fulfilment of the Outdoor Emergencies Company element. This finding indicates that, although the site's internal emergency system was relatively well developed, formal arrangements for emergencies occurring outside the company's operational area were insufficiently documented. This

issue is particularly relevant because hazardous-material transportation and other activities outside the site involve third-party organizations and resources beyond the direct control of the mining contractor.

The absence of formal external emergency arrangements may create uncertainty regarding reporting, communication, external roles, resource mobilization, and post-incident coordination, particularly when response requires rapid cooperation with contractors, transport providers, emergency services, and healthcare facilities. ERP should therefore extend beyond company boundaries through documented external response procedures, updated emergency contacts, clear notification and escalation mechanisms, defined resource responsibilities, and joint exercises with external responders. This component-level finding is important because the preparedness gap was not evident from the overall 86.5% ISRS fulfilment score.

Recent evidence further shows that formal emergency teams and communication systems must be supported by effective coordination. O'Brien et al. (2020) emphasized information sharing and situational awareness, while Waring et al. (2020) identified coordination difficulties even where formal response structures existed. These findings support performance-based exercises to assess communication, coordination, and decision-making during emergencies.

### Implications for continuous improvement

The findings demonstrate the usefulness of the ISRS framework as a structured diagnostic tool for identifying both strengths and specific gaps in ERP implementation. The principal contribution of the assessment is not to demonstrate that ERP reduces occupational accidents, but to quantify the current level of preparedness and identify areas requiring corrective action.

Based on the findings, improvement priorities include developing and formally documenting external emergency-response arrangements, establishing clear reporting and coordination procedures for off-site emergencies, strengthening coordination with third-party contractors and transportation providers, improving spill and leak control, extending first-aid training to all designated personnel, and strengthening documentation of lessons learned from emergency exercises and incidents. Periodic reassessment using the same structured framework would enable the company to determine whether corrective actions have

addressed previously identified deficiencies and whether preparedness has improved over time.

The importance of external coordination is well established in mining emergency research. Gyllencreutz et al. (2020) identified multi-agency collaboration and joint practices as essential for managing mining incidents, while O'Brien et al. (2020) emphasized timely information sharing across organizational boundaries. Waring et al. (2020) further showed that coordination problems may persist when agencies lack effective shared decision-making. These findings support the interpretation that undocumented off-site emergency arrangements represent a substantive preparedness weakness rather than a minor administrative gap.

### Integration of islamic values

The findings may be interpreted within the Islamic principle of preserving human life (*hifz al-nafs*), one of the fundamental objectives of *maqasid al-shariah*. Islam emphasizes the prevention of harm and the protection of individuals from avoidable danger. The Qur'an states in Surah Al-Ma'idah verse 32:

*"Whoever saves one life, it is as if they saved all of humanity."*

In the context of occupational safety, this principle reinforces the ethical responsibility of organizations to establish effective emergency preparedness systems that protect workers before, during, and after critical incidents. The identified priorities in this study, including strengthening external emergency coordination, improving first-aid competency, enhancing hazardous-material spill and leak response, and maintaining effective rescue capacity, can therefore be viewed as practical expressions of the obligation to safeguard life and minimize preventable harm. This interpretation is also consistent with the Prophetic principle:

*"There should be neither harm nor reciprocating harm."*

Accordingly, emergency preparedness should not be regarded solely as a regulatory or technical requirement, but also as an organizational responsibility to prevent foreseeable harm to workers and surrounding communities. Integrating the Islamic values of preserving life, preventing harm, responsibility, and preparedness with evidence-based occupational safety practices may strengthen the ethical foundation of emergency management while complementing existing scientific, professional, and regulatory standards.

### Strengths and limitations

A major strength of this study was the use of a structured ISRS framework supported by multiple sources of evidence, including document review, field observation, and interviews. This triangulation enabled the assessment to distinguish between formally documented arrangements and evidence of their operational implementation. Component-level scoring also allowed specific preparedness deficiencies to be identified despite a relatively high overall fulfilment score.

Several limitations should nevertheless be considered. First, this was a single-site case study; therefore, the findings reflect ERP conditions at Abadi Site MLP Ltd. and should not be generalized to the mining industry as a whole. Second, the assessment was conducted between May and July 2026 and represents preparedness during a specific period. Third, some findings depended on organizational documentation and interview information, which may be influenced by incomplete records or reporting bias. Fourth, although standardized criteria, multiple evidence sources, and assessor consensus were used, some degree of judgment in determining ISRS fulfilment could not be completely eliminated. Fifth, the study assessed preparedness and compliance rather than actual emergency-response performance and did not measure response time, rescue effectiveness, communication performance during real emergencies, injury severity, morbidity, mortality, or accident rates. Consequently, no causal relationship between ERP fulfilment and occupational safety outcomes can be inferred. Future research should incorporate multi-site assessments, repeated measurements, independent assessors, performance-based emergency simulations, and longitudinal evaluation of occupational safety outcomes.

### CONCLUSIONS

Emergency Response Preparedness at Abadi Site MLP Ltd. achieved an overall ISRS fulfilment level of 86.5%, corresponding to 558 of 645 applicable points. The site demonstrated strong internal preparedness, with seven elements achieving full fulfilment and high performance in the Emergency State Plan, First Aid in Accidents, and Protection and Rescue System. However, the Outdoor Emergencies Company element received no points, indicating a major gap in documented preparedness for emergencies occurring outside the company's

operational area. Additional improvement needs were identified in spill and leak control and first-aid training coverage.

The component-level ISRS assessment was useful for identifying preparedness gaps that could be overlooked when relying only on an overall compliance score. Priority actions should include formalizing external emergency arrangements, strengthening coordination with third-party contractors, transportation providers, external responders, and mutual-aid partners, improving spill and leak control, and expanding first-aid training. Because this was a single-site assessment, the findings should not be generalized to the wider mining sector. Periodic reassessment and performance-based emergency exercises are recommended to evaluate whether corrective actions result in stronger operational emergency-response capability.

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### AUTHORS' CONTRIBUTIONS

Rindang Diannita designed and formulated the study and reviewed the manuscript. Nur Miftahur Ridha wrote the manuscript, collected and analyzed data, and conducted fieldwork. Sisca Mayang Phuspa revised and reviewed the manuscript; Aisy Rahmania revised the manuscript. All authors have read and approved the final manuscript.

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### COMPETING INTERESTS

The author(s) declare no potential conflict of interest with respect to the research, authorship, and/or publication of this article.

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