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Hazard Identification, Risk Assessment, and Determining Control (HIRADC) for Workplace Safety in Manufacturing Industry: A Risk-Control Framework Compelete with Bibliometric Literature Review Analysis to Support Sustainable Development Goals (SDGs)

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A B S T R A C T

This study implements the Hazard Identification, Risk Assessment, and Determining Control (HIRADC) method to evaluate and mitigate occupational risks in the manufacturing construction sector. A bibliometric analysis reveals a growing yet insufficient number of studies applying structured risk control frameworks like HIRADC in industrial settings, particularly in developing countries. Using a descriptive approach, data were collected through field observations, interviews, and document analysis. Seven hazards were identified, resulting in five low-risk and two moderate-risk classifications using a probability–severity matrix. Control measures were implemented following ISO 45001:2018 standards, including engineering controls, administrative actions, and personal protective equipment (PPE). The results demonstrate that HIRADC enhances workplace safety awareness and reduces risk levels. This study contributes a practical safety framework for manufacturing environments while reinforcing the relevance of SDG-aligned and bibliometrically justified research in occupational health.

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1. INTRODUCTION

The manufacturing industry is recognized as one of the most high-risk sectors due to the intensity and complexity of its operational activities. Workplace accidents in this sector not only result in significant health and safety concerns for workers but also lead to substantial economic losses for companies (Adamopoulos & Syrou, 2022). In response to these risks, the concept of Occupational Health and Safety (OHS) has been widely adopted as a preventive framework designed to reduce injuries, diseases, and fatalities in industrial environments (Ashari, 2022). OHS represents a condition where workers are free from physical harm, emotional stress, and work-related illnesses, thereby ensuring a safe and efficient production process (Micheli *et al*., 2022).

Accidents in the workplace demand serious attention, as they can interrupt operational continuity, decrease employee morale, and impair overall productivity (Achmad *et al*. 2021). To address this, organizations are expected to implement comprehensive safety systems to protect workers from physical, mental, and emotional hazards (Jain *et al*., 2021). Maintaining a safe and healthy work environment is not only a legal and ethical responsibility but also a strategic requirement for sustainable industrial performance. One of the structured and widely accepted approaches for managing occupational risks is the Hazard Identification, Risk Assessment, and Determining Control (HIRADC) method (Rotinsulu *et al*., 2023), which serves as a foundation for identifying threats and applying appropriate control measures in the workplace.

A bibliometric search using the query "hazard AND identification AND risk AND assessment AND determining AND control" across scopus indexed databases revealed a total of 81 scientific publications from 1994 to 2025. Detailed information regarding the use of bibliometric analysis is explained elsewhere (Rochman *et al*., 2024; Al Husaeni & Nandiyanto, 2022; Al Husaeni & Al Husaeni, 2022). As shown in **Figure 1**, the number of studies has increased significantly over the past decade, with a notable peak in 2024. Several examples of references published regarding HIRADC is presented in **Table 1**. Despite this upward trend, many of these publications focus primarily on theoretical models or generalized industrial contexts, with limited application in real-world environments such as construction-related manufacturing sectors. Moreover, very few studies integrate the HIRADC method with actual field observations, operational data, and structured risk control frameworks. This gap becomes more critical in developing countries, where occupational safety systems often lack standardization, contextual adaptation, or data-driven intervention. The need for localized, empirical studies applying HIRADC in specific industrial sectors is evident. Therefore, this research contributes to the literature by applying HIRADC within an Indonesian manufacturing setting, offering both practical value and alignment with global safety standards such as ISO 45001:2018.

Table 1. Previous study regarding hazard identification, risk assessment, and determining control.

No	Title	References
1	Neonicotinoids in bees: a review on concentrations, side-effects and risk assessment	(Blacquiere *et al.*, 2012)
2	Ecotoxicology of metals in aquatic sediments: binding and release, bioavailability, risk assessment, and remediation	(Chapman *et al.*, 1998)

Table 1 (continue). Previous study regarding hazard identification, risk assessment, and determining control.

No	Title	References
3	Association between HIV infection and the risk of heart failure with reduced ejection fraction and preserved ejection fraction in the antiretroviral therapy era: results from the Veterans Aging Cohort Study	(Freiberg *et al*., 2017)
4	Risk assessment in shellfish-borne outbreaks of hepatitis A	(Pinto *et al*., 2009)
5	Microseismic precursory characteristics of rock burst hazard in mining areas near a large residual coal pillar: a case study from Xuzhuang coal mine, Xuzhou, China	(Cao *et al*., 2016)
6	Strategy for genotoxicity testing: hazard identification and risk assessment in relation to in vitro testing	(Thybaud *et al*., 2007)
7	Assessment of the potential health risks of heavy metals in soils in a coastal industrial region of the Yangtze River Delta	(Hu *et al*., 2017)
8	Risk-based leak analysis of an lpg storage tank: a case study	(Munahar *et al*., 2022)
9	Novel motion planning strategy with fuzzy logic for improving safety in autonomous vehicles in response to risky road user behaviors	(Pohan *et al*., 2024)
10	Correlates schools disaster risk reduction and management (DRRM) implementation and school performance in safety and readiness: basis for enhanced action plan	(Pandapatan, 2025)

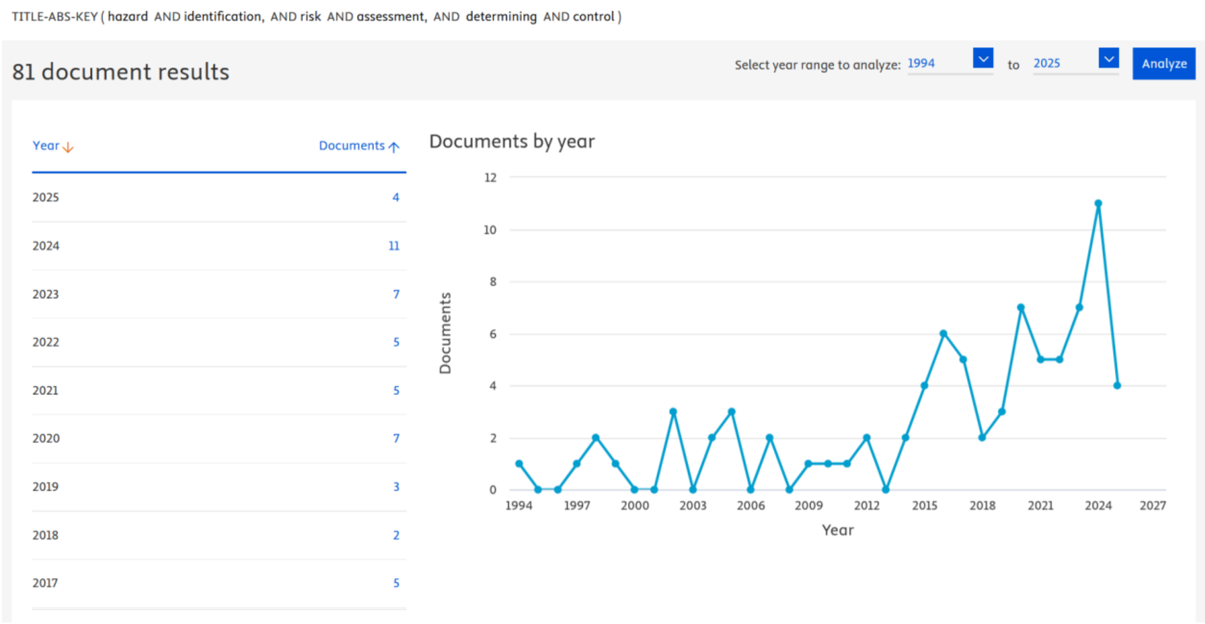

Figure 1. Bibliometric trend of hiradc-related publications (1994–2025)

This study directly supports two key targets within the United Nations Sustainable Development Goals (SDGs). First, it aligns with SDG 3: Good Health and Well-being, particularly Target 3.9, which seeks to reduce deaths and illnesses caused by hazardous environments. Indeed, this will add new information regarding SDGs as shown in **Table 2**. By identifying and controlling workplace hazards using the HIRADC method, this study promotes proactive occupational risk management to safeguard the physical and mental health of industrial workers. Second, it contributes to SDG 8: Decent Work and Economic Growth, particularly Target 8.8, which emphasizes the protection of labor rights and the promotion of safe and secure working conditions for all. The implementation of structured hazard control in manufacturing environments not only enhances worker safety but also improves overall productivity and organizational sustainability. Therefore, this research provides a practical pathway for industries to align with global development agendas while strengthening internal occupational health and safety systems.

Table 2. Previous studies regarding SDGs.

No	Title	References
1	Low-carbon food consumption for solving climate change mitigation: Literature review with bibliometric and simple calculation application for cultivating sustainability consciousness in facing sustainable development goals (SDGs)	(Nurramadhani *et al.*, 2024)
2	Towards sustainable wind energy: A systematic review of airfoil and blade technologies over the past 25 years for supporting sustainable development goals (SDGs)	(Krishnan *et al.*, 2024)
3	Assessment of student awareness and application of eco-friendly curriculum and technologies in Indonesian higher education for supporting sustainable development goals (SDGs): A case study on environmental challenges	(Djirong *et al.*, 2024)
4	Effect of substrate and water on cultivation of Sumba seaworm (nyale) and experimental practicum design for improving critical and creative thinking skills of prospective science teacher in biology and supporting sustainable development goals (SDGs)	(Kerans *et al.*, 2024)
5	Smart learning as transformative impact of technology: A paradigm for accomplishing sustainable development goals (SDGs) in education	(Makinde *et al.*, 2024)
6	The relationship of vocational education skills in agribusiness processing agricultural products in achieving sustainable development goals (SDGs)	(Gemil *et al.*, 2024)
7	The influence of environmentally friendly packaging on consumer interest in implementing zero waste in the food industry to meet sustainable development goals (SDGs) needs	(Haq *et al.*, 2024)
8	Sustainable packaging: Bioplastics as a low-carbon future step for the sustainable development goals (SDGs)	(Basnur *et al.*, 2024)
9	Implementation of sustainable development goals (SDGs) no. 12: Responsible production and consumption by optimizing lemon commodities and community empowerment to reduce household waste	(Maulana *et al.*, 2023)
10	Analysis of the application of mediterranean diet patterns on sustainability to support the achievement of sustainable development goals (SDGs): Zero hunger, good health and well beings, responsible consumption, and production	(Nurnabila *et al.*, 2023)
11	Efforts to improve sustainable development goals (SDGs) through education on diversification of food using infographic: Animal and vegetable protein	(Awalussillmi *et al.*, 2023)
12	Safe food treatment technology: The key to realizing the sustainable development goals (SDGs) zero hunger and optimal health	(Rahmah *et al.*, 2024)
13	Analysis of student's awareness of sustainable diet in reducing carbon footprint to support sustainable development goals (SDGs) 2030	(Keisyafa *et al.*, 2024)

Although the HIRADC method is widely recommended by international standards such as ISO 45001:2018 and national regulations like Indonesia's Government Regulation No. 50 of 2012, its structured application remains underutilized in specific industrial sectors, particularly in medium-scale manufacturing environments. Many companies still rely on generic safety practices without a systematic risk assessment framework, leading to inconsistent hazard control measures and recurring accidents.

The lack of contextualized studies that apply HIRADC in Indonesian industrial settings highlights the need for practical frameworks that integrate field-based risk identification, quantification, and control. Therefore, this study aims to apply the HIRADC method to evaluate occupational hazards in the construction division of a manufacturing company and to determine effective risk control strategies based on ISO 45001 standards. The objective is to demonstrate that structured implementation of HIRADC can significantly reduce risk levels and strengthen the overall Occupational Health and Safety (OHS) management system. The novelty of this study lies in its contextual application of the HIRADC method within a real-world construction setting in the manufacturing sector, which remains underrepresented in existing literature. While bibliometric data indicate a growing number of studies on occupational risk management, few have empirically integrated hazard identification, risk assessment, and control measures based on ISO 45001:2018 in mid-scale Indonesian industries. This research addresses that gap by combining field data with a structured risk matrix, offering practical control strategies grounded in actual workplace observations. Furthermore, by aligning the study with Sustainable Development Goals (SDGs) 3 and 8, the research demonstrates how localized industrial safety practices can contribute to global development agendas, thereby bridging the divide between theoretical models and applied OHS management in developing contexts.

2. METHOD

This study employed a descriptive qualitative approach focusing on hazard assessment in the construction division of a manufacturing company. Data were collected through direct field observations, interviews with selected workers, and document analysis, including Job Safety Analysis (JSA), Standard Operating Procedures (SOPs), and company incident records. These methods supported identifying and evaluating workplace hazards using the HIRADC framework following ISO 45001:2018 standards (Saputro & Lombardo, 2021). A detailed flowchart regarding HIRADC is presented in **Figure 2**.

A detailed risk matrix diagram is in **Figure 3**. The risk assessment stage involved two key parameters: probability of occurrence and severity of consequences. Each hazard was rated using a five-level probability scale ranging from “rare” to “almost certain,” and a five-level severity scale from “insignificant” to “catastrophic” (presented in **Tables 3-6**) (Babakhanov, 2023). These two factors were multiplied to calculate the risk value based on the formula: Risk = Probability × Severity.

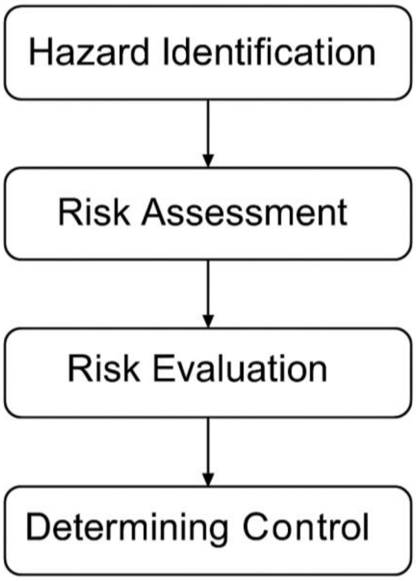

Figure 2. HIRADC process flowchart in the manufacturing setting.

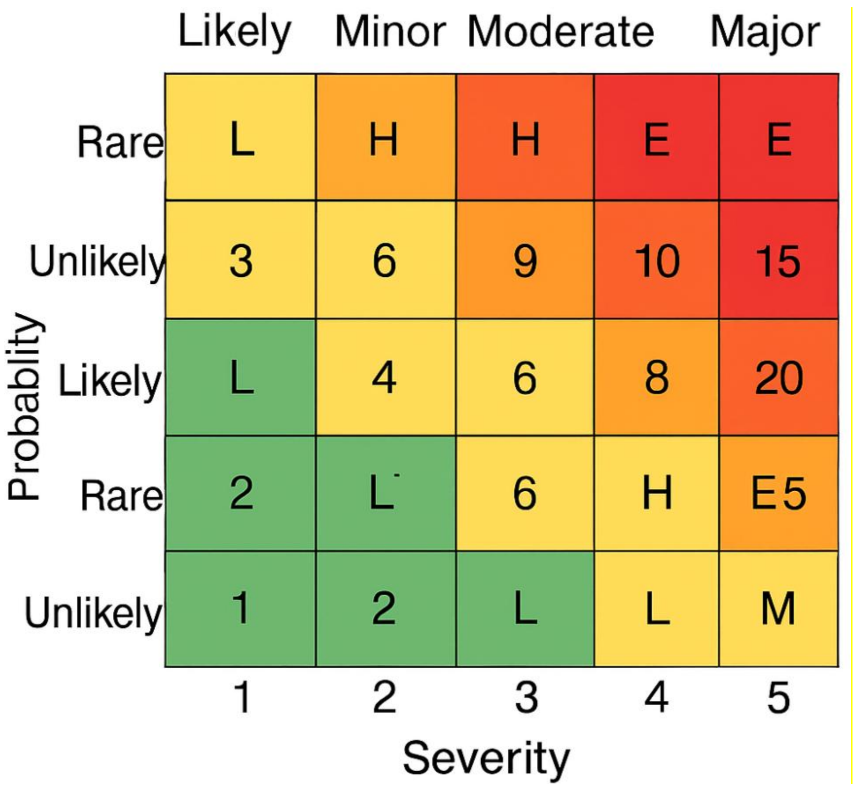

Figure 3. Risk matrix diagram based on probability and severity (5x5 grid).

Table 3. Probability levels of hazard occurrence.

Level	Criteria	Description
5	Almost Certain	Occurs very frequently
4	Likely	Occurs frequently
3	Possible	Occurs occasionally
2	Unlikely	Occurs very rarely
1	Rare	Almost never occurs

Table 4. Severity levels of potential hazards.

Level	Criteria	Description
1	Insignificant	No injuries, minor losses
2	Minor	Minor injuries require treatment by the medical unit, moderate losses
3	Moderate	Lost workdays, requires hospital treatment, considerable losses
4	Major	Severe physical injuries, significant financial or operational losses
5	Catastrophic	Causes death, extremely high losses

Table 5. Risk matrix for hazard evaluation.

Probability ↓ / Severity →	**1 (Insignificant)**	**2 (Minor)**	**3 (Moderate)**	**4 (Major)**	**5 (Catastrophic)**
5 (Almost Certain)	M (5)	H (10)	E (15)	E (20)	E (25)
4 (Likely)	M (4)	H (8)	H (12)	E (16)	E (20)
3 (Possible)	L (3)	M (6)	H (9)	H (12)	E (15)
2 (Unlikely)	L (2)	M (4)	M (6)	H (8)	H (10)
1 (Rare)	L (1)	L (2)	L (3)	M (4)	M (5)

Note: L = Low Risk; M = Moderate Risk; H = High Risk; E = Extreme Risk.

The risk matrix used in this study is displayed in **Table 5**, providing a visual classification of risk levels from low to extreme (Ihsan, Hamidi, and Putri 2020). Each calculated risk value was then interpreted using the descriptors outlined in **Table 6**, which defined the appropriate control actions required for each category (Supriyadi, Ahmad Nalhadi, and Abu Rizaal 2015).

This structured methodology allowed the study to identify risks, prioritize control measures, and propose safety interventions tailored to the specific operational context of the construction unit.

Table 6. Risk level matrix description.

Category	Description
Extreme	Extreme risk, requires immediate and serious handling.
High	High risk, requires training or seminars by management and prompt corrective actions.
Moderate	Moderate risk, handling is carried out by specific management.
Low	Low-risk, routine procedural control is implemented.

3. RESULTS AND DISCUSSION

3.1. Hazard Identification

The hazard identification process was conducted through direct field observations, interviews with relevant workers, and document analysis, including incident logs, Job Safety Analysis (JSA), and Standard Operating Procedures (SOPs). Seven major work activities were identified in the construction area as having significant potential risks. These include pipe lifting, pipe bending, pipe punching, grinding, welding, polishing, and mattress pressing operations (Mishra & Aithal, 2021).

Each activity presented specific hazards. Pipe lifting posed risks of falling objects causing physical injury; bending and punching processes risked hand entrapment in machines; grinding and welding exposed workers to sharp fragments, sparks, and fumes; polishing involved mechanical entrapment and inhalation of glue vapors; and mattress pressing machines risked hand injuries due to lack of safety barriers. These observations are consistent with previous studies emphasizing the vulnerability of manual operations in industrial settings (Ihsan *et al*., 2020).

These hazards are summarized in **Table 7**, which outlines each work activity along with its associated risks. The table provides a structured overview of the most common and critical hazards observed in the field.

Hazards were categorized systematically according to HIRADC standards as recommended in ISO 45001:2018, which stresses the need for structured hazard identification in dynamic work environments (Saputro & Lombardo, 2021). This phase provided the foundation for subsequent risk evaluation by determining which activities posed consistent threats to workers due to insufficient engineering controls, weak PPE compliance, and minimal warning signage. Such identification supports the need for proactive safety measures in the manufacturing industry (Fadhilah *et al*., 2023).

Table 7. Identified potential hazards in the construction area.

No.	Activity	Potential Hazard
1	Pipe lifting process	Pipes falling on the body or other body parts; bone fractures if struck by a heavy pipe.
2	Pipe bending process	Hands getting caught in the bending machine.
3	Pipe punching process	Hands getting caught in the punching machine.
4	Grinding process	Hands being cut and metal chips hitting the eyes or other body parts.
5	Welding process	Sparks hitting the face or other body parts; welding light causing vision disturbance; breathing difficulties.
6	Polishing process	Hands getting caught in the polishing machine, breathing difficulties, and fumes from polishing glue.
7	Pressing process	Hands getting caught in the mattress press machine.

3.2. Risk Evaluation based on Probability and Severity

After identifying seven major hazards, each was evaluated using the risk assessment formula Risk = Probability × Severity (Gul & Ak, 2018). The probability scores were assigned based on field observations and frequency of occurrence, as shown in **Table 8**, while severity levels were rated based on potential consequences, presented in **Table 9**. These values were then used to calculate the final risk scores for each activity, as summarized in **Table 10**.

For example, the pipe lifting process received a probability rating of 3 and a severity rating of 1, resulting in a risk score of 3, categorized as low risk. Similarly, the pipe bending and mattress pressing processes both scored 4 for probability and 1 for severity, resulting in a risk score of 4, also within the low to moderate range. Other activities such as grinding, welding, and punching also fell into the low-risk category, with consistent severity scores of 1 and probability values ranging from 2 to 3.

The use of a structured risk matrix ensured consistency in evaluation and allowed for visual categorization of all hazards based on combined risk levels. These results highlight that while none of the activities reached high or extreme risk, attention must still be given to moderate-level hazards that require scheduled intervention (Cash *et al*., 2013). This evaluation serves as the foundation for determining specific control strategies, which are discussed in the next section.

Table 8. Probability values for each hazardous activity.

No.	Activity	Probability	Potential Hazard
1	Pipe lifting process	3	Pipes falling on the body or other body parts; bone fractures if struck by a heavy pipe.
2	Pipe bending process	4	Hands getting caught in the bending machine.
3	Pipe punching process	3	Hands getting caught in the punching machine.
4	Grinding process	3	Hands being cut and metal chips hitting the eyes or other body parts.
5	Welding process	3	Sparks hitting the face or other body parts; welding light causing vision disturbance; breathing difficulties.
6	Polishing process	2	Hands getting caught in the polishing machine, breathing difficulties, and fumes from polishing glue.
7	Pressing process	4	Hands getting caught in the mattress press machine.

Table 9. Severity values for each hazardous activity.

No.	Activity	Severity	Potential Hazard
1	Pipe lifting process	1	Pipes falling on the body or other body parts; bone fractures if struck by a heavy pipe.
2	Pipe bending process	1	Hands getting caught in the bending machine.
3	Pipe punching process	1	Hands getting caught in the punching machine.
4	Grinding process	1	Hands being cut and metal chips hitting the eyes or other body parts.
5	Welding process	1	Sparks hitting the face or other body parts; welding light causing vision disturbance; breathing difficulties.
6	Polishing process	1	Hands getting caught in the polishing machine, breathing difficulties, and fumes from polishing glue.
7	Pressing process	1	Hands getting caught in the mattress press machine.

Table 10. Hazard risk rating based on probability and severity.

No.	Activity	Probability	Severity	Risk Rating (P × S)
1	Pipe lifting process	3	1	3
2	Pipe bending process	4	1	4
3	Pipe punching process	3	1	3
4	Grinding process	3	1	3
5	Welding process	3	1	3
6	Polishing process	2	1	2
7	Pressing process	4	1	4

3.3. Risk Classification and Control Implementation

Based on the calculated risk scores, each activity was classified into appropriate risk categories using the descriptors outlined in the risk matrix (see **Table 5**). The classification results are summarized in **Table 11**, which shows that five hazards were classified as low risk, while two hazards (pipe bending and mattress pressing) were categorized as moderate risk. No activity was identified as high or extreme risk.

Following the principles of ISO 45001:2018, each risk was addressed using the hierarchy of risk control, which prioritizes interventions from most to least effective: elimination, substitution, engineering controls, administrative controls, and personal protective equipment (PPE) (see **Figure 4**) (Lestari *et al*., 2022).

Control measures were then developed for each identified hazard. These are presented in **Table 11**, which details specific interventions for each hazard. For example, the risk of falling pipes was mitigated by installing hoist cranes and placing visual warning signs. For machinery-related risks such as hand entrapment in bending and punching machines, engineering controls such as safety sensors were installed, supported by administrative controls like SOPs and mandatory signage.

Furthermore, consistent use of PPE such as gloves, helmets, safety glasses, masks, and aprons were enforced across all workstations. These measures are aligned with both national OHS guidelines and international safety standards, ensuring that even low-risk activities are monitored and controlled systematically (Fadhilah *et al*., 2023).

By applying a layered and structured approach to risk control, this study demonstrates the practical utility of HIRADC as a proactive tool in minimizing occupational hazards and promoting safety awareness among workers.

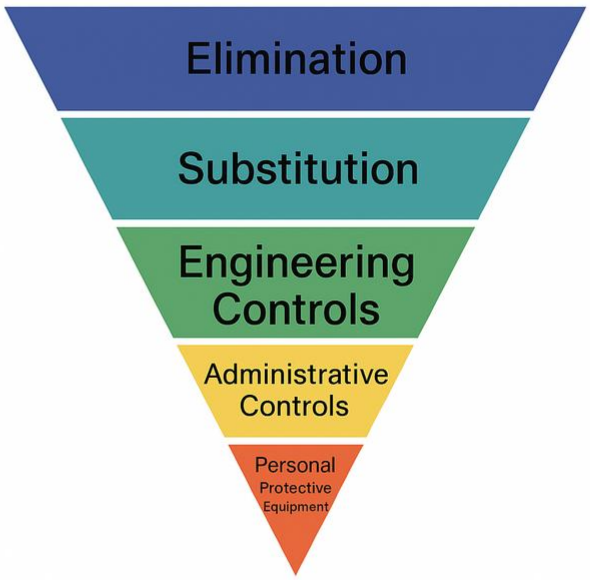

Figure 4. Hierarchy of risk control based on iso 45001:2018.

Table 11. Hazard risk control measures based on control hierarchy.

No.	Potential Hazard	Elimination	Substitution	Engineering Controls	Administrative Controls	PPE
1	Pipes falling on the body or other body parts; bone fractures if struck by a heavy pipe.	–	–	Use of a hoist crane	Install hazard signs: “Caution: Falling Hazard”, “Mandatory PPE Area”	Safety shoes, safety helmet
2	Hands getting caught in the bending machine.	–	–	Add machine sensors	Sign: “Maintain a Safe Distance”	Safety gloves, apron, earplugs

Table 11 (continue). Hazard risk control measures based on control hierarchy.

No.	Potential Hazard	Elimination	Substitution	Engineering Controls	Administrative Controls	PPE
3	Hands getting caught in the punching machine.	–	–	Add machine sensors	Sign: "Mandatory PPE Area"	Safety gloves, apron, earplugs
4	Hands being cut and metal chips hitting eyes or body parts.	–	–	–	Signs: "Clean PPE After Use", "Mandatory PPE Area"	Gloves, fire-resistant apron, safety glasses, shoes, earplugs
5	Sparks hitting face or body; welding light causing vision disturbance; breathing difficulties.	-	-	Add turbine ventilators for air	Signs: "Caution: Falling Hazard", "Mandatory PPE Area"	Safety gloves, fire-resistant apron, welding mask, safety shoes
6	Hands getting caught in the polishing machine, breathing difficulties, and fumes from the glue.	-	-	Add turbine ventilators for air circulation.	Sign: "Mandatory PPE Area"	Safety glasses, mask, leather apron
7	Hands getting caught in the mattress press machine.	-	-	Add machine sensors	Sign: "Mandatory PPE Area"	Safety gloves, apron, safety shoes

3.4. Integration of Human Factors and Ergonomics

While the primary focus of this study is on technical hazard identification and control, the integration of human factors and ergonomics is essential to ensure a comprehensive approach to occupational risk management. Industrial settings, particularly those involving manual processes, are heavily influenced by the way workers interact with equipment, physical workload, posture, and repetitive motion—all of which are critical determinants of long-term health and safety (Korshunov *et al*., 2020).

In this study, several hazards identified, such as hand proximity to machines and exposure to fumes, are directly related to ergonomic risks. However, most interventions still prioritize engineering and administrative controls, with limited emphasis on adapting workstations or processes to human capabilities. For instance, bending and pressing activities require forceful exertions and awkward body positions, which can lead to musculoskeletal disorders (Marwah *et al*., 2024).

To enhance risk control effectiveness, future improvements should consider ergonomically informed designs, such as adjustable machine heights, improved grip tools, anti-fatigue floor mats, and rest cycle scheduling. Incorporating human factors not only reduces physical strain but also enhances compliance with safety procedures by aligning tasks with workers' comfort and cognitive limitations (Shamsuddin *et al*., 2015).

The limited integration of ergonomic principles observed in this setting indicates an area for further development. As industries aim for sustainable safety performance, the combination of HIRADC with ergonomic assessment tools, such as RULA or REBA, can provide a more holistic risk evaluation. This would ultimately support both SDG 3 (health) and SDG 8 (decent work) through human-centered safety design.

3.5. Benchmarking and Comparison with Related Studies

To contextualize the findings, it is important to compare this study with related HIRADC-based research in other industrial settings. Shamsuddin *et al*. (2015) conducted a study applying HIRADC in a Malaysian manufacturing facility and emphasized its effectiveness in reducing incident rates when combined with employee participation and continuous monitoring. HIRADC in mining operations at PT Semen Padang, highlighting that high-risk zones were successfully reclassified into moderate categories through improved controls and task-specific training.

Compared to those studies, this research focuses on a more localized and specific environment—a construction-oriented division within a manufacturing company in Indonesia—providing a context-sensitive application of HIRADC. While prior studies often examined broader industrial systems or theoretical frameworks, this study incorporates actual field-based risk classification and real-time control implementations, particularly in small and repetitive task environments.

Another comparative reference is the work of Ihsan *et al*. (2020), who assessed risk in a high-rise building project and found that physical proximity to equipment significantly increased hazard probability. The findings of the present study mirror this trend, especially in the pipe bending and pressing activities, where inadequate safety spacing was a recurring concern.

Despite methodological similarities, this study distinguishes itself by linking its outcomes directly to SDG targets and emphasizing operational feasibility within the constraints of medium-scale industries. The combination of bibliometric grounding, standardized evaluation matrices, and layered risk control strategies reinforces its contribution to both academic discourse and industrial best practices.

3.6. Practical Relevance to Workplace Safety

The implementation of the HIRADC method in this study demonstrates tangible benefits for enhancing occupational safety in the manufacturing and construction sectors. By systematically identifying and evaluating seven high-frequency activities, this study provides a model for structured risk management that can be adapted to similar industrial settings. The categorization of risks into low and moderate levels, with none falling into the high or extreme categories, illustrates the effectiveness of preemptive hazard identification and the practical feasibility of targeted control measures.

This approach allows companies to prioritize resources toward risks with greater impact while maintaining baseline protection in lower-risk activities. For instance, the decision to install machine sensors and hazard signage in areas such as the bending and pressing stations is not only cost-effective but also sustainable when reinforced through administrative controls and consistent PPE usage (Tanisri *et* al., 2024). These measures can reduce the probability of injury and enhance worker awareness without requiring significant infrastructure changes.

Moreover, the process fosters a culture of safety by actively involving workers in hazard recognition and response planning. This participatory model is essential in medium-scale industries, where safety departments often operate with limited personnel and budget. Aligning with ISO 45001:2018, the study's findings reinforce that even basic control interventions—when applied systematically—can result in meaningful improvements to workplace conditions.

Ultimately, this research provides a replicable and scalable risk control framework that supports the integration of safety practices into daily operations, reinforcing both compliance and productivity in industrial environments.

3.7. Contribution to SDGs and Industrial Safety

This study contributes meaningfully to the advancement of Sustainable Development Goals (SDGs), particularly SDG 3: Good Health and Well-being and SDG 8: Decent Work and Economic Growth. Through the structured application of HIRADC, the study addresses SDG 3.9, which emphasizes reducing health problems arising from hazardous workplace conditions. By identifying and minimizing exposure to physical injuries, chemical fumes, and ergonomic hazards, the findings contribute to creating a safer work environment that supports both short- and long-term health outcomes for workers.

In alignment with SDG 8.8, the study promotes labor rights by advocating for consistent safety procedures and risk reduction strategies. The risk classification system implemented here offers a framework for safeguarding worker welfare and ensuring compliance with international safety standards such as ISO 45001:2018. This is particularly relevant for medium-sized industrial settings in developing countries, where occupational health systems are still evolving and require localized yet globally informed solutions.

Moreover, the study reinforces the notion that sustainable industrial productivity cannot be separated from safe working conditions. The proactive risk control measures are detailed, ranging from machine-level engineering controls to behavioral interventions, and demonstrate that even small-scale changes can yield significant improvements when applied systematically.

By grounding its methodology in bibliometric analysis and aligning its practical outcomes with global goals, this research not only enhances workplace safety but also strengthens the integration of SDG principles into operational practices within the industrial sector.

3.8. Policy and Practice Implications

The results of this study offer critical insights for policymakers, safety managers, and industry practitioners seeking to enhance occupational health systems through structured hazard control. The use of the HIRADC method, supported by ISO 45001:2018 principles, demonstrates a scalable approach for industrial environments that often lack comprehensive safety frameworks. This is particularly relevant in developing regions where regulatory enforcement is inconsistent and safety planning is reactive rather than preventive (Durand, 1996).

From a policy perspective, this study supports the integration of standardized risk assessment procedures into national occupational health guidelines. Regulators may consider promoting mandatory implementation of HIRADC-based assessments in high-risk sectors, such as manufacturing and construction, to improve baseline safety performance and reduce accident rates. Furthermore, the inclusion of ergonomic assessments and participatory safety audits can be encouraged to promote human-centered policy design.

In terms of practice, the study provides actionable recommendations for operational supervisors and safety officers. Control strategies such as hazard signage, PPE enforcement, and installation of engineering safeguards can be implemented with relatively low cost but high impact. Training modules can also be revised to include scenario-based simulations that reflect actual hazard patterns identified in this study.

The research underscores the need for continuous monitoring and revaluation of risks, allowing companies to evolve their safety strategies as operational conditions change. By embedding structured risk control into daily workflows, organizations can shift from compliance-driven behavior to a proactive safety culture.

3.9. Limitations and Future Research

While this study provides practical insights into hazard identification and risk control in a manufacturing construction context, several limitations should be acknowledged. First, the scope was limited to a single company's construction division, which may restrict the generalizability of the findings to other sectors or larger industrial environments. A broader sample across multiple companies would enhance the robustness and applicability of the HIRADC framework in diverse operational contexts.

Second, although this study implemented a comprehensive risk assessment, it did not incorporate quantitative measurements such as frequency-based injury rates, absenteeism data, or long-term health outcomes. Future research could integrate such metrics to provide a more data-driven evaluation of the effectiveness of control measures over time.

Third, the study did not fully explore ergonomic risk assessment tools such as RULA or REBA, which could provide deeper insight into posture-related and biomechanical hazards. Including these tools in future research would strengthen the integration of human factors into occupational safety strategies.

Additionally, the control measures implemented were mostly engineering and administrative, with limited evaluation of their long-term behavioral impact. Longitudinal studies examining worker compliance, safety culture evolution, and the sustainability of interventions would offer a richer understanding of risk mitigation effectiveness.

Despite these limitations, this study establishes a practical foundation for the localized application of HIRADC, and future studies are encouraged to build upon its framework to support improved policy development, training design, and SDG-aligned safety innovation in the industrial sector.

4. CONCLUSION

This study applied the Hazard Identification, Risk Assessment, and Determining Control (HIRADC) framework to assess and manage occupational risks in the construction division of a manufacturing company. Through direct observation, interviews, and analysis of workplace documentation, seven key hazardous activities were identified. Using a structured risk matrix, five were classified as low risk and two as moderate risk, with none falling into the high or extreme categories. These results reflect the effectiveness of early detection and systematic classification of workplace hazards.

Control measures were implemented based on the hierarchy outlined in ISO 45001:2018, including engineering solutions, administrative protocols, and personal protective equipment (PPE). Although the study primarily focused on technical and procedural interventions, it also underscored the importance of integrating human factors and ergonomics into occupational safety planning. Moreover, the findings contribute to Sustainable Development Goals (SDG) 3 and 8 by promoting health, safety, and decent work in industrial settings.

Despite limitations in sample size, quantitative data, and ergonomic scope, the study offers a replicable model for small and medium enterprises aiming to strengthen their Occupational

Health and Safety (OHS) management systems. Future research should expand on these findings by incorporating broader organizational benchmarking, long-term compliance monitoring, and ergonomic risk analysis. Ultimately, this research demonstrates that structured risk management through HIRADC can significantly reduce workplace hazards and promote a culture of safety grounded in global sustainability goals.

5. AUTHORS' NOTE

The authors declare that there is no conflict of interest regarding the publication of this article. Authors confirmed that the paper was free of plagiarism.

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