ANALYSIS OF OCCUPATIONAL SAFETY AND HEALTH RISK MANAGEMENT IN METAL INDUSTRY PRODUCTION AREAS USING THE HIRA METHOD

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ABSTRACT
Background : The informal metal industry poses a high risk of hazards but often escapes oversight of Occupational Safety and Health (K3) standards. The lack of systematic risk management in these environments exposes workers to a variety of hazards, ranging from ergonomic, mechanical, physical, and chemical, all of which can potentially lead to accidents and occupational illnesses.
Objective: The purpose of the research is to identify potential hazards, assess the level of risk in each production area, and formulate effective control alternatives to minimize work incidents.
Methods: The research method used was descriptive quantitative with the Hazard Identification and Risk Assessment (HIRA) approach. This approach was used to analyze all activities in nine production areas through the stages of hazard identification, likelihood and severity assessment, and risk level determination. Data was collected through direct observation and worker interviews, and validated using secondary data from Job Safety Analysis (JSA) and previous incident reports.
Results: The research results showed that there were 11 findings of high hazard risks, 11 moderate hazard risks and 7 low hazard risks in all production areas.
Conclusion: It can be concluded that the application of the HIRA method is essential for risk management in the informal metal industry. It is recommended to implement hierarchical controls, ranging from engineering controls such as the installation of machine guards and ventilation systems, to administrative controls such as the development of stricter SOPs and regular OHS training.

Keywords: Metal Industry, Occupational Safety and Health, Risk Management

BACKGROUND

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Human resources (HR) are a fundamental asset and a key pillar in accelerating economic development and a country's competitiveness on the global stage. The quality and productivity of HR directly determine the innovation capacity and efficiency of national industry. Protecting HR is no longer merely a normative obligation, but rather a crucial strategic investment to ensure sustainable productivity. Without guaranteed safety and health protection, HR's full potential will never be achieved and they even risk becoming a demographic burden due to high rates of work-related disability and death.

The development paradigm focused on human resources faces significant challenges in developing countries like Indonesia, where the economic structure is dominated by the informal sector. The latest data from the Central Statistics Agency (BPS) as of February 2025 shows that 59.7% of the total national workforce is absorbed in this sector. The informal sector, which includes micro, small, and independent businesses, operates within a regulatory "grey zone" characterized by the absence of formal employment contracts, minimal access to social security, and, most worryingly, a near-inability to comply with Occupational Safety and Health (OSH) supervision and standards.

Occupational Safety and Health (OSH) is a multidimensional discipline and application aimed at protecting workers from all potential risks, preventing workplace accidents, and minimizing occupational diseases, in order to create a safe, healthy, and productive work environment. The absence of a structured Occupational Safety and Health culture and system in the informal sector directly exposes millions of workers to uncontrolled hazards. This contrasts with the formal sector, which is bound by strict regulations such as Government Regulation No. According to Law No. 50 of 2012 concerning the Occupational Health and Safety Management System (SMK3), informal industry workers often work with rudimentary equipment, without adequate personal protective equipment (PPE), and in non-ergonomic work environments. Consequently, the prevalence of workplace accidents and occupational diseases (PAK) is not accurately recorded but is estimated to be very high. This phenomenon represents the "tip of the iceberg" in national labor statistics, where reported figures are only the tip of a much more massive and systemic problem at the lower levels of the economy.

The impact of this negligence in Occupational Health and Safety is extremely worrying. A joint report by the World Health Organization (WHO) and the International Labour Organization (ILO) in July 2025 estimated that more than 2.8 million worker deaths globally each year are caused by work-related accidents and diseases, with the largest contribution coming from the informal sector in lower-middle-income countries. Data from the Social Security Agency (BPJS Ketenagakerjaan) through the second quarter of 2025 does show tens of thousands of reported workplace accidents, but this figure only reflects registered workers in the formal sector. Experts project that the real number of incidents in the informal sector could be 10 to 15 times higher than the official data, making it a hidden humanitarian and economic crisis.

To reduce or eliminate hazards that can cause workplace accidents, risk management is required, encompassing hazard identification, potential hazard analysis, risk assessment, risk control, and monitoring and evaluation. The process of identifying and analyzing potential hazards can be conducted using the Hazard Identification and Risk Assessment (HIRA) method. HIRA aims to identify potential hazards in the workplace by linking workers, tasks, work equipment, and the work environment (Agnella and Utami, 2021).

While HIRA has proven highly effective and is the main foundation of Occupational Safety and Health Management Systems in formal industries, its implementation in the informal sector remains a significant challenge and an underexplored area of research. One workplace with several potential hazards is the metal industry. In metal industry installations, services include plate cutting and engineering, bordering/flat plate, plate punching, lathing, welding, and plate rolling services. Furthermore, numerous mechanical machines are used to provide engineering services that are inherently dangerous, hot, and sharp. Consequently, risk management for occupational safety and health is crucial. Therefore, the research entitled "Analysis of Occupational Safety and Health Risk Management for Industrial Workers in the Metal Industry. Using the HIRA Method" is very essential and urgent. This research aims to identify and analyze specifically the potential hazards and risks faced by industrial workers in the informal sector, especially in the metal industry, and formulate a practical and applicable application of the HIRA method according to the unique characteristics of the sector, as a concrete step to protect the nation's most vulnerable Human Resources assets.

OBJECTIVE

The Objective from this research is to determine the application of Hazard Identification and Risk Assessment (HIRA) in an effort to reduce potential hazards in the workplace in the Metal Industry.

METHODS

The research was conducted using a qualitative descriptive approach. The study was conducted in the production area of the Metal Industry in Sidoarjo Regency. The study was conducted from August to September 2025. This study analyzed the risk of occupational accidents using the HIRA method, which is the process of identifying hazards that occur in all company activities, then conducting a risk assessment of these hazards and providing control recommendations.

Occupational risk analysis can be viewed through two aspects: probability and severity (ILO, 2018). The assessment process includes the level of likelihood. The level of likelihood of an accident or occupational illness must consider how often and for how long a worker is exposed to the potential hazard. This allows for a decision about the frequency of accidents for each identified potential hazard. The next step is the severity. Determining the severity of an accident also requires considering how many people are affected by the accident and which parts of the body are exposed to the potential hazard.

RESULTS

In the Sidoarjo metal industry, hazard identification analysis is carried out on the production process which consists of several stages/areas starting from raw material storage, cutting, pressing, punching, welding, finishing, plating, packaging and product loading. During the processing process, machines are operated, except for raw material storage. Based on the results of observations and interviews, the identification and assessment of risks/hazards at PT. X are presented in Table 1.

Table 1. Hazard Identification and Risk Assessment (HIRA) Results

Process	Hazard	Consequence	P	S	R	Control
Procurement of iron stock	Ergonomic hazards when lifting manually (heavy metal loads can cause aches and pains in workers)	Low back pain, bruises, broken bones	3	3	*Medium (9)*	Using lifting equipment (trolley/forklift), wearing PPE (safety shoes, gloves)
	Placing raw materials in a high position	Tripping and being hit by a foot can result in bruises, broken bones, scratches	2	3	*Medium (6)*	
	The storage area is too narrow so that workers' activities are slightly disturbed due to limited movement.	workers being trapped	1	2	*Low(2)*	
Iron cutting	Being hit by a cutting machine because the machine does not have a safety device, which can cause worker injury.	Causes the risk of cuts and being hit by metal fragments, eye irritation, hearing loss so that workers can operate the tool not in accordance with procedures.	3	4	*High (12)*	Wearing PPE (safety glasses, gloves, earplugs), installing machine guards, Work SOP's
	Absence of machine operating procedures	Causing injury to workers	1	1	*Low* (1)	
	Iron pieces placed below pose a risk for workers to trip over them	Causes minor injuries	2	2	*Low* (4)	

Process	Hazard	Consequence	P	S	R	Control
Iron formation	Hand or finger caught in press/mold machine	Crush wounds, bruises, amputations	2	5	*High* (10)	Use of a two-hand control system, wear PPE (gloves), work SOP
	Iron pieces placed below pose a risk for workers to trip over them	Causes minor injuries	2	2	*Low* (4)	
	Dark areas, poor lighting, and poor air circulation	Possibility of causing injury	2	2	*Low* (4)	
	Inadequate electrical installation	Causes risk of electric shock	2	2	*Low* (4)	
Iron punching/hole punching	Hands trapped, sharp metal fragments hit the body	Puncture wounds, scratches, eye irritation	3	3	*Mediu m* (9)	Wear PPE (safety glasses, gloves), use a brush/magnet to clean debris.
	Small scratches or wounds	May cause disruption in job performance	2	2	*Low* (4)	
	Oil spills on the floor of the punch machine area	Decrease in safety performance index leading to an increase in the frequency of work accidents	3	3	*Mediu m* (9)	
Iron welding	Exposure to welding rays (UV/IR), welding fumes, electric shock, and sparks	Arc eye, respiratory problems, burns, fire, fatal electric shock	4	3	*High* (12)	Use PPE (welding mask, leather gloves, apron), adequate ventilation (exhaust fan), provide APAR.
	Extreme heat and molten metal splashes	Direct burns to the skin or eyes	3	3	*Mediu m* (9)	
	Dust spray during the welding process	Long-term inhalation and worsening of respiratory conditions	4	4	*High* (16)	

Process	Hazard	Consequence	P	S	R	Control
Iron polishing	Noise, vibration, contact with grinding stone	hearing loss, hand-arm vibration syndrome (HAVS), lacerations/abrasions	4	4	*High* (16)	Wearing PPE (N95 mask, safety glasses, ear plugs/muffs, gloves), having a dust collector.
	Hot metal flakes	Eye injuries, skin burns, and cuts	3	3	*Medium* (9)	
	Iron dust particles flying	Respiratory disorders and eye irritation	3	3	*Medium* (9)	
Chrome coloring/coating	Exposure to vapors and splashes of hazardous chemicals (acids, chrome solutions)	Skin & eye irritation, poisoning, respiratory disorders, environmental pollution	3	4	*High* (12)	Wear complete PPE (respirator, goggles, chemical gloves, apron, boots), ventilation (fume hood), MSDS available .
	Metal exposure during the plating process	Long-term inhalation	3	3	*Medium* (9)	
Packaging	Repetitive movements, non-ergonomic working postures, sharp edges on products/packaging	Muscle and joint pain (MSDs), lacerations	3	2	*Medium* (6)	Using complete PPE, ergonomic work station design .
	Lifting or moving heavy spare parts boxes	Back injury, muscle strain, or musculoskeletal disorder	3	3	*Medium* (9)	
	Exposure to metal dust or residue from the powder coating/chroming process that sticks to the product or chemicals on the packaging	Skin/eye irritation, respiratory problems, or poisoning	4	4	*High* (16)	
Delivery	Manually lifting	Back injury, crush	3	3	*Mediu*	Using a trolley,

Process	Hazard	Consequence	P	S	R	Control
	heavy loads, items falling during loading, traffic accidents	injury, asset damage, fatal injury			*m* (9)	ensuring the load is securely tied, checking the vehicle before leaving.
	Collisions between forklifts and pedestrians, failure of the transport equipment brakes, or load instability	Serious injuries such as broken bones, internal injuries	4	4	*High* (16)	
	Unstable stacking of goods on warehouse shelves or during loading into containers/trucks, especially if spare parts are packed in large boxes without strong fasteners.	Head injuries, bruises, or crushing caused by falling cargo and product damage	4	4	*High* (16)	Use proper and strong binding tools and transport tools that are appropriate to the capacity.
	Workers may be exposed to chemical residues from the production process.	Skin irritation, respiratory problems, or chronic poisoning	4	4	*High* (16)	Use PPE in accordance with SOP
	The presence of flammable materials such as oil or plastic packaging in the delivery area	Burns, smoke asphyxiation, or fatal damage in the warehouse area	4	4	*High* (16)	

Based on the results of hazard identification and risk assessment using the Hazard Identification and Risk Assessment (HIRA) method in the metal industry production process in Sidoarjo Regency, various potential hazards were identified, with varying levels of risk from low to high, across all work stages. Based on the HIRA Table 1, the risk values for each production process vary from low (R=1–4), moderate (R=6–9), to high-extreme (R≥10).

Low to moderate risks were generally found in the procurement and storage of raw materials, which were dominated by ergonomic hazards and tripping risks. Meanwhile, high risks were often found in the cutting, forming, punching, welding, grinding, chemical coating, and product distribution processes. The main hazards included mechanical injury, exposure to noise, metal dust and fumes, hazardous chemicals, and the risk of accidents resulting from lifting and transporting activities and the use of heavy equipment.
Welding, grinding, and chrome plating processes exhibited the highest levels of risk, particularly related to exposure to fumes, metal dust, extreme heat, and chemicals, which have the potential to cause respiratory problems, serious injuries, and even poisoning. Although some controls have been implemented through the use of personal protective equipment, work procedures, and ventilation, comprehensive risk control is still needed to reduce the risk of accidents and occupational diseases.

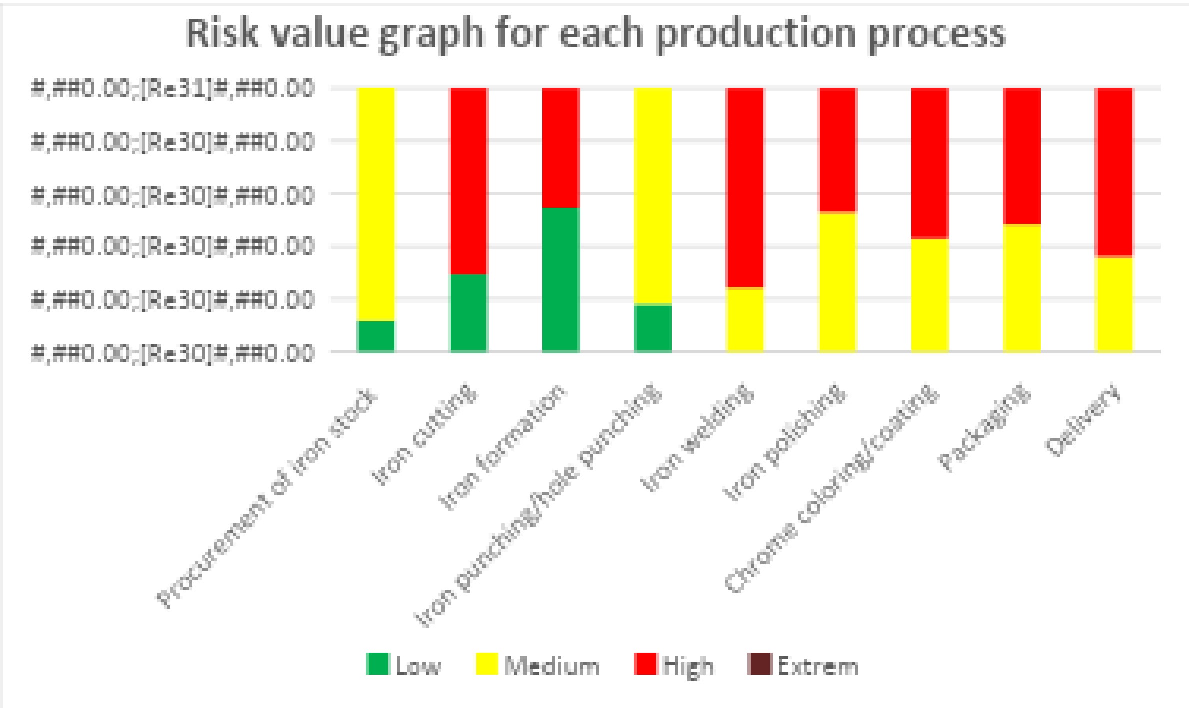

Figure 1. Risk value graph for each production process

Based on Figure 1, the graph shows the number of risk findings in each production process, categorized as low, medium, high, and extreme. The process with the highest number of risks is the loading/distribution area (5 findings), which is dominated by high to extreme risk findings (R=16–20). Next, the welding and cutting machine areas each have 4 risk findings, with a predominance of high risks (R=12–16). In the press and punching machines, 3–4 risk findings were found in the medium to high category (R=9–10). Meanwhile, raw material storage, finishing/grinding, coating, and packaging activities have fewer risks, which are generally in the low to medium category (R=2–9). These findings indicate that the loading/distribution, welding, and cutting machine processes are the main priorities in risk control.

DISCUSSION

After collecting and processing data regarding risk findings in the production process at metal industry and its risk levels, there are 11 risk findings that fall into the highest (high) category, 11 risk findings that fall into the medium category, and 7 risk findings that fall into the lowest (low) category. The following is a further explanation.

Low Risk Findings and Risk Assessment

Based on the research results, seven low-risk risks were identified, namely in the raw material transportation, metal cutting, pressing, and punching processes. Low-risk hazards include being crushed due to limited space, which limits activity during the raw material transportation process; the risk of cuts during the metal cutting process; the risk of workers tripping; inadequate lighting and air circulation during the pressing process; and injuries during the punching process. Control measures include administrative controls and personal protective equipment (PPE). Control over the raw material transportation process can be achieved by implementing the 5S (5S) in the raw material storage process, making it easier for workers to select and transport materials (Rantung, *et al,* 2018). The 5S (Seiri, Seiton, Seiso, Seketsu, Shitsuke) method is an effective method for warehouse management (Qowim et al., 2020). Control over the risk of cuts can be achieved through engineering techniques, including the use of safe and comfortable hand tools; administrative controls include providing training and education on the hazards and impacts of using these tools; and providing operational procedures. Personal protective equipment (PPE) controls can be implemented to prevent worker exposure to hazards by using gloves and safety shoes to prevent cuts and abrasions from work tools on the hands and feet while working (Saputra and Widodo, 2023)

Moderate Risk Findings and Risk Assessment

Based on the research results, 11 risks were identified as moderate, including those encountered in the raw material transportation, punching, welding, finishing, plating, packing, and loading processes. Moderate risks include ergonomic hazards during raw material transportation, hands being trapped during the punching process, exposure to extreme heat, metal chips during the welding process, heat and fine iron dust particles, and molten metal splashes during the finishing process, metal exposure during the plating process, repetitive movements and non-ergonomic work postures during the packing process, and the risk of being crushed during the loading process. Based on these findings, control measures are necessary. One control measure that has been implemented is providing personal protective equipment such as gloves and safety shoes. Although the hazard is considered moderate, in-depth control is still necessary, considering the frequency of occurrence. Other possible controls include administrative controls for the potential hazards of inhaling dust, including providing training and education on the hazards and impacts of inhaling dust. This is intended to help workers recognize the hazards early and change bad habits into good ones. This emphasizes the mental attitude of workers. Risk control for potential noise hazards can be achieved by rotating and scheduling work based on exposure dose calculations according to threshold values, as well as conducting initial, periodic, and specific health checks. If administrative controls are not feasible, the use of PPE in the form of earplugs is mandatory for workers in areas with high noise levels. This is consistent with Martino et al., who stated that risk control for potential noise hazards cannot be achieved using elimination controls, substitution controls, and engineering controls because they can impact and disrupt the production process. Therefore, administrative controls and the use of PPE are essential.

High Risk Findings and Risk Assessment

Based on the research results, 11 high-risk findings were identified, including those in the cutting, pressing, welding, finishing, plating, packing, and loading processes. High-risk hazards include injury risks such as fingers being cut during the cutting process, hands being caught in the machine during the pressing process, exposure to noise and vibration during the finishing process, exposure to hazardous chemical splashes (acid, chrome solution) in the plating area, exposure to metal dust or residue from the powder coating/chroming process in the packing area, the risk of load instability during the loading process, failure of the conveyor brakes and load instability during the loading process. The highest risk finding was exposure to UV light, sparks, and material debris during the welding process, which can cause visual impairment, skin burns, and even fires. This is consistent with research by Saputra and Widodo (2023), which stated that these activities have a high risk because they can cause burns and blisters. Sparks originate from the combustion of liquids, which workers may come into contact with during pouring. Based on the highest risk findings, control measures can be implemented by ensuring that employees in the smelting area wear masks and comply with work instructions. Signs are installed in hazardous areas, specifically the smelting machine. Current control measures include administrative controls, which include regular checks of work equipment and procedures, and PPE usage controls to ensure the availability of protective PPE, including long-sleeved clothing, long pants, and heat-resistant gloves. Employees are also required to wear complete PPE.

CONCLUSION

Based on the research results, the conclusion is that there were 11 high-risk hazards, 11 moderate-risk hazards, and 7 low-risk hazards. Based on this, controls that can be implemented to mitigate workplace hazards include engineering controls, administrative controls, and the use of PPE. Engineering controls are a top priority. Recommendations include installing machine guards in cutting and pressing areas, installing local ventilation systems (exhaust fans) in welding and plating areas, and installing safety sensors on press machines. Administrative controls require the development of stricter Standard Operating Procedures (SOPs), job rotations to reduce monotonous exposure, and regular OHS training for all workers. Furthermore, controls on the use of Personal Protective Equipment (PPE) should be implemented by ensuring the availability and consistently enforcing the use of appropriate PPE, such as welding masks, respirators, cut-resistant and chemical-resistant gloves, and ear protection.

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CONFLICTS OF INTEREST

There were no obstacles in implementing the research

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