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Occupational health and safety risk control using the HIRADC approach in the sugar processing industry

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A R T I C L E I N F O

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Sugar processing industry,
Workplace hazards.

A B S T R A C T

Occupational Health and Safety (OHS) risk control is an essential aspect of industrial workplace management, particularly in sectors with high exposure to mechanical, physical, chemical, ergonomic, biological, and psychosocial hazards. This study aimed to analyze OHS risk control practices in a sugar processing industry using the Hazard Identification, Risk Assessment, and Determining Control (HIRADC) approach. A descriptive qualitative method was applied through workplace observation and risk control analysis at PT X Lampung. The results identified several potential workplace hazards, including rotating machinery, heavy equipment, high noise exposure, dust and airborne particles, hazardous chemicals, high working temperatures, electrical hazards, poor ergonomics, slippery floors, inadequate lighting, biological hazards, radiation exposure, and work-related stress. Risk control measures were implemented through engineering controls, administrative controls, and the use of personal protective equipment. These measures contributed to reducing workplace risks, improving worker safety, supporting health protection, and maintaining operational productivity. However, improvements are still needed in ergonomic training, periodic OHS inspections, safety compliance monitoring, and continuous hazard evaluation. This study highlights that the HIRADC-based OHS risk control approach can serve as an effective framework for creating a safer, healthier, and more productive work environment in the sugar processing industry.

1. Introduction

Occupational Health and Safety (OHS) is an essential component of workplace management, particularly in industrial sectors that involve complex production processes, heavy machinery, chemical substances, high temperatures, noise exposure, and ergonomic risks. The implementation of OHS is not only intended to protect workers from accidents and occupational diseases but also to support productivity, operational efficiency, and organizational sustainability. In industrial workplaces, failure to control occupational hazards may result in injuries, disabilities, fatalities, production disruptions, financial losses, and reduced employee performance [1, 2].

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The sugar processing industry is one of the industrial sectors with diverse occupational hazards. Production activities commonly involve rotating machinery, boilers, conveyors, high-temperature processes, dust exposure, chemical use, electrical systems, and manual handling activities. These conditions may expose workers to physical, mechanical, chemical, ergonomic, biological, and psychosocial risks. If these hazards are not systematically identified and controlled, they can increase the probability of workplace accidents and occupational health problems. Therefore, a structured risk management approach is required to ensure that workplace hazards are properly recognized, assessed, and controlled [3–5].

One widely used approach in occupational risk management is Hazard Identification, Risk Assessment, and Determining Control (HIRADC). This approach enables companies to identify potential hazards, evaluate the level of risk, and determine appropriate control measures based on the hierarchy of controls. Risk control may include hazard elimination, substitution, engineering controls, administrative controls, and the use of personal protective equipment. Through the application of HIRADC, companies can develop preventive strategies to minimize workplace incidents and promote a safer working environment [6, 7].

In Indonesia, the implementation of OHS is supported by regulations and standards, including Law Number 1 of 1970 concerning Work Safety and Government Regulation Number 50 of 2012 concerning the Implementation of Occupational Health and Safety Management Systems. In addition, international standards such as ISO 45001:2018 emphasize the importance of systematic occupational health and safety management to prevent work-related injuries and illnesses. These regulations and standards highlight that OHS should be implemented continuously and integrated into company management systems [8–10].

Previous studies and workplace safety practices indicate that effective OHS risk control contributes to reducing workplace accidents, improving worker awareness, enhancing safety compliance, and supporting productivity. However, in many industrial settings, challenges remain in ensuring consistent implementation, particularly in ergonomic practices, routine inspections, worker training, and compliance with personal protective equipment use. Therefore, continuous evaluation of OHS implementation is necessary to identify gaps and improve workplace safety performance [3, 11].

Based on this background, this study aims to analyze Occupational Health and Safety risk control in the sugar processing industry using the HIRADC approach. The study focuses on identifying workplace hazards, evaluating existing control measures, and describing the implementation of engineering controls, administrative controls, and personal protective equipment. The findings are expected to contribute to the improvement of workplace safety, worker health protection, and productivity in industrial work environments.

2. Materials and Methods

2.1. Study design and location

This study used a descriptive qualitative approach to analyze Occupational Health and Safety (OHS) risk control in the sugar processing industry. The descriptive qualitative method was selected because this study focused on identifying workplace hazards, describing existing risk control practices, and evaluating the implementation of OHS measures based on field conditions [12, 13]. The analysis was conducted using the Hazar Identification, Risk Assessment, and Determining Control (HIRADC) approach.

The study was conducted at PT X Lampung, a company engaged in the sugar processing industry. The production process in this industry involves various activities that may generate occupational hazards, including the operation of rotating machinery, heavy equipment, boilers, conveyors, chemical handling, high-temperature processes, electrical systems, and manual material handling. These activities make the sugar processing industry an appropriate setting for assessing OHS risk control implementation.

2.2. Data collection

Data were collected through workplace observation and document-based analysis related to occupational health and safety practices. Observations were focused on identifying potential hazards in the work environment, including mechanical, physical, chemical, ergonomic, biological, electrical, fire, and psychosocial hazards. The observed risk sources included rotating machinery, heavy equipment, noise exposure, dust and airborne particles, hazardous chemicals, high working temperatures, poor ergonomics, inadequate lighting, slippery floors, radiation exposure, and work-related stress.

In addition, the study examined the types of control measures applied in the workplace, including engineering controls, administrative controls, and the use of personal protective equipment. The information was then organized into a risk control table to describe the relationship between hazard sources, possible impacts, control measures, and required protective equipment.

2.3. HIRADC-based risk analysis

The risk analysis was conducted using the HIRADC framework, which consists of three main stages: hazard identification, risk assessment, and determining control. In the hazard identification stage, potential sources of danger in the workplace were identified based on observation of production activities and work conditions. In the risk assessment stage, each hazard was evaluated based on its possible impact on worker safety and health. In the determining control stage, appropriate control measures were classified according to the hierarchy of risk control. The control measures were grouped into three main categories:

1. Engineering controls, such as machine guards, ventilation systems, dust collectors, grounding systems, fire protection systems, safety panels, guard rails, and ergonomic workplace design.
2. Administrative controls, including standard operating procedures, operator training, work permits, job rotation, routine inspections, safety signs, emergency response procedures, workload management, and safety compliance monitoring.
3. Personal protective equipment, including helmets, gloves, safety shoes, respirator masks, earplugs, earmuffs, goggles, insulated gloves, anti-slip shoes, and full body harnesses.

2.4. Data analysis

The collected data were analyzed descriptively by comparing identified hazards with the existing control measures implemented at PT X Lampung. Each hazard was reviewed based on its potential impact on workers and the adequacy of the applied risk control measures. The analysis emphasized whether the implemented controls were able to reduce occupational risks and support a safer, healthier, and more productive work environment.

The findings were interpreted to identify the strengths and weaknesses of OHS implementation in the company. Particular attention was given to areas requiring improvement, such as ergonomic training, periodic OHS inspections, safety compliance monitoring, and continuous hazard evaluation. This approach allowed the study to provide practical recommendations for improving OHS risk control in the sugar processing industry.

3. Results and discussion

3.1. Hazard identification in the sugar processing industry

The results of workplace observation showed that the sugar processing industry has various potential hazards that may affect worker safety, health, and productivity. These hazards were mainly associated with production activities involving rotating machinery, heavy equipment, boilers, conveyors, chemical handling, high-temperature processes, electrical systems, and manual material handling [6, 14, 15]. Based on the Hazard Identification, Risk Assessment, and Determining Control (HIRADC) approach, the identified hazards were classified into mechanical, physical, chemical, ergonomic, biological, electrical, fire, environmental, and psychosocial risks [4, 16].

The most dominant hazards identified in the workplace included rotating machinery, high noise exposure, dust and airborne particles, hazardous chemicals, high working temperatures, electrical hazards, poor ergonomics, slippery floors, inadequate lighting, and work-related stress [17, 18]. These hazards may lead to injuries, hearing impairment, respiratory disorders, chemical irritation, heat stress, electric shock, musculoskeletal disorders, slips and falls, eye strain, and decreased productivity [3, 6, 16]. Therefore, appropriate control measures are needed to reduce the likelihood and severity of occupational accidents and work-related health problems [24]. The summary of occupational hazards, potential impacts, and applied control measures is presented in **Table 1**.

The identified hazards indicate that occupational risks in the sugar processing industry are multidimensional. Mechanical hazards are mainly related to rotating machinery and heavy equipment, while physical hazards include noise, heat, vibration, lighting, and radiation. Chemical hazards are associated with reagent use during the production process, whereas ergonomic hazards arise from manual handling, repetitive work, and poor working posture [14, 22, 23]. These findings confirm that the sugar processing industry requires an integrated OHS risk control system rather than a single control approach.

3.2. Implementation of OHS risk control

The implementation of OHS risk control in the sugar processing industry was carried out through three main control strategies: engineering controls, administrative controls, and the use of personal protective equipment. These controls are consistent with the hierarchy of risk control, in which hazards should be reduced as much as possible through technical and managerial interventions before relying on personal protective equipment. Engineering controls were applied by modifying the work environment and equipment to reduce worker exposure to hazards. These included machine guards, emergency stop systems, ventilation systems, dust collectors, fire protection facilities, grounding systems, guard rails, safety panels, and ergonomic workstation design. Engineering controls are important because they can reduce hazards at the source and provide a more reliable form of protection compared with controls that depend only on worker behavior [20, 21, 25].

Administrative controls were also implemented to regulate work procedures and improve safety compliance. These included standard operating procedures, operator training, work permits, job rotation, work time limitations, internal inspections, safety signs, emergency response procedures, chemical safety training, and Lock Out Tag Out procedures. Administrative controls play an important role in ensuring that workers understand potential hazards and follow safe work practices during production activities. The use of personal protective equipment was applied as the final layer of protection. Workers were required to use safety helmets, gloves, safety shoes, respirator masks, earplugs, earmuffs, goggles, insulated gloves, anti-slip shoes, and full body harnesses depending on the type of hazard in each work area. Although PPE is important, its effectiveness depends on proper selection, correct use, worker discipline, and regular supervision.

Table 1
Occupational health and safety risk control in the sugar processing industry

No	Hazard/Risk Source	Potential Impact	Control Measures
1	Rotating machinery and heavy equipment	Injury, amputation, fatality	Machine guards, emergency stop buttons, operating SOPs, operator training, work permits, helmets, gloves, and safety shoes
2	High noise exposure	Hearing impairment	Sound dampeners, machine isolation, work time limits, job rotation, earplugs, and earmuffs
3	Dust and airborne particles	Respiratory disorders and pneumoconiosis	Local exhaust ventilation, dust collectors, routine housekeeping, environmental inspections, and respirator masks
4	Hazardous chemicals	Poisoning, skin irritation, and eye irritation	Ventilation systems, enclosed chemical handling, MSDS/SDS availability, chemical safety training, gloves, and goggles
5	High working temperature	Heat stress and dehydration	Ventilation, air conditioning, adequate rest breaks, drinking water provision, and lightweight work clothing
6	Fire risk	Burns, property damage, and fatality	Fire extinguishers, hydrants, fire alarms, evacuation drills, emergency response SOPs, helmets, and fire suits
7	High-voltage electricity	Electric shock and fatality	Grounding systems, safety panels, Lock Out Tag Out procedures, electrical work permits, and insulated gloves
8	Poor work ergonomics	Muscle pain, low back pain, and musculoskeletal disorders	Ergonomic workstation design, workplace stretching, job rotation, and back support when necessary
9	Working at heights	Fracture and fatality	Guard rails, safety nets, working-at-height permits, and full body harnesses
10	Biological hazards	Disease infection	Sterilization, good ventilation, worker immunization, medical waste procedures, masks, and gloves
11	Equipment vibration	Nerve and muscle disorders	Vibration dampeners, equipment usage duration limits, and anti-vibration gloves
12	Inadequate lighting	Eye strain and workplace accidents	Additional work lamps, routine lighting inspections, and protective glasses when needed
13	Slippery floors	Slips and falls	Anti-slip surfaces, hazard warning signs, routine cleaning, and anti-slip shoes
14	Radiation exposure	Body tissue damage	Radiation shielding, exposure monitoring, and lead aprons
15	Work-related stress	Fatigue and decreased productivity	Comfortable workspace, counseling, workload management, and psychosocial support

3.3. Effectiveness of the HIRADC approach

The application of the HIRADC approach provided a systematic framework for identifying hazards, assessing their potential impacts, and determining appropriate control measures. Through hazard identification, the company was able to recognize various risk sources that could cause workplace accidents or occupational diseases. Through risk assessment, each hazard could be evaluated based on its possible consequences for worker safety and health. Through determining control, the company could select appropriate measures to minimize risk exposure [16, 26, 27].

The results show that the implementation of OHS risk control contributed to the improvement of workplace safety and operational productivity. A safer work environment can reduce the possibility of accidents, near-miss incidents, absenteeism, production delays, and equipment damage. In addition, effective OHS implementation can

improve worker confidence, concentration, and motivation. This condition supports better work performance and helps maintain the continuity of the production process. In the context of industrial management, OHS should not only be viewed as a regulatory obligation but also as a strategic investment [14, 22, 23]. Proper risk control can reduce accident-related costs, protect workers, improve company reputation, and support long-term business sustainability. Therefore, the HIRADC approach is relevant for strengthening occupational safety and health management in the sugar processing industry.

3.4. Areas requiring improvement

Although OHS risk control had been implemented in several workplace areas, some aspects still require improvement. First, ergonomic training should be strengthened, especially for workers involved in manual handling, repetitive movements, and long-duration standing activities. Poor ergonomic practices may increase the risk of musculoskeletal disorders, low back pain, and work fatigue [28, 29].

Second, periodic OHS inspections should be conducted more consistently to ensure that safety procedures are properly followed. Regular inspections are needed to identify unsafe conditions, damaged equipment, poor housekeeping, incomplete safety signs, and non-compliance with PPE use. Third, safety compliance monitoring should be improved through supervision, worker involvement, and continuous safety education [14, 22, 23].

Fourth, hazard evaluation should be carried out continuously because workplace conditions may change due to production demands, equipment modification, worker rotation, or environmental factors. Continuous evaluation allows the company to update control measures and prevent new risks from developing. Therefore, the implementation of HIRADC should be performed not only as a one-time assessment but also as an ongoing process within the occupational health and safety management system [19–21].

Overall, the findings indicate that HIRADC-based OHS risk control is effective in supporting a safer, healthier, and more productive work environment in the sugar processing industry. The integration of engineering controls, administrative controls, and PPE can reduce occupational risks and strengthen the company's safety culture. However, continuous improvement is still necessary, particularly in ergonomic management, routine inspection, safety monitoring, and worker participation. This is consistent with the initial article content, which emphasizes risk control, workplace hazards, HIRADC, PPE, ergonomic training, periodic inspections, and productivity improvement in PT X Lampung.

4. Conclusion

This study demonstrated that Occupational Health and Safety (OHS) risk control in the sugar processing industry can be systematically implemented using the Hazard Identification, Risk Assessment, and Determining Control (HIRADC) approach. The results showed that the work environment contains various potential hazards, including mechanical, physical, chemical, ergonomic, biological, electrical, fire, environmental, and psychosocial risks. These hazards may affect worker safety, health, productivity, and the continuity of industrial operations if they are not properly controlled.

The implementation of risk control measures through engineering controls, administrative controls, and the use of personal protective equipment has an important role in reducing workplace hazards and preventing occupational accidents and diseases. Engineering controls such as machine guards, ventilation systems, dust collectors, grounding systems, fire protection facilities, and ergonomic workplace design help minimize hazards at the source. Administrative controls, including standard operating procedures, worker training, work permits, job rotation, routine inspections, and safety compliance monitoring, support safer work behavior and improve organizational safety culture. Personal protective equipment provides an additional layer of protection for workers exposed to specific hazards.

Overall, the HIRADC-based OHS risk control approach contributes to creating a safer, healthier, and more productive work environment in the sugar processing industry. However, continuous improvement is still needed, particularly in ergonomic training, periodic OHS inspections, worker safety awareness, and consistent monitoring of personal protective equipment use. Therefore, OHS risk control should be implemented as an ongoing process and integrated into the company's occupational health and safety management system to support worker protection, operational efficiency, and sustainable industrial productivity. This conclusion is consistent with the article's focus on OHS, HIRADC, workplace hazards, PPE, ergonomic training, and productivity improvement.

CRediT authorship contribution statement

Rinto Haardianto: Writing – original draft, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Selvia Anggraeni**: Writing – original draft, Methodology, Investigation, Formal analysis, Data curation. **Festy Ladyani**: Writing – review & editing, Supervision, Validation, Resources, Conceptualization. **Muhammad Rizky Ramadhan**: Investigation, Data curation, Formal analysis, Writing – original draft. **Karenina MA**: Investigation, Data curation, Formal analysis. **Keisha NA**: Investigation, Data curation, Formal analysis. **Khanza GP**: Investigation, Data curation, Formal analysis. **Komang DN**: Investigation, Data curation, Formal analysis. **Lefi SS**: Investigation, Data curation, Formal analysis. **Luh Paramita AD**: Investigation, Data curation, Formal analysis. **Made Egy VA**: Investigation, Data curation, Formal analysis. **Mifa Ramadhani Putri**: Investigation, Data curation, Formal analysis, Writing – review & editing. **Muhammad Riko H**: Investigation, Data curation, Formal analysis, Writing – review & editing.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

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