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Occupational Hazard Identification and Workplace Safety Control Practices in a Sugar Manufacturing Facility: A Descriptive Observational Study in Lampung, Indonesia

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Abstract

Sugar manufacturing facilities involve complex industrial operations that expose workers to various occupational hazards, including machinery-related risks, noise, vibration, heat, airborne dust, and ergonomic stressors. Identifying these hazards and assessing existing workplace safety controls are important components of occupational injury prevention and occupational health management. This study aimed to identify potential workplace hazards and describe occupational safety control practices at a sugar manufacturing facility in Lampung, Indonesia. A descriptive observational study was conducted through a workplace walkthrough survey at PT X Lampung on May 7, 2026. Data collection involved direct workplace observations, an occupational health and safety (OHS) checklist, brief interviews with company personnel, and a review of available workplace safety information. The assessment focused on physical, chemical, mechanical, ergonomic, and organizational hazards, as well as existing preventive controls, personal protective equipment (PPE), emergency preparedness, and occupational health surveillance. Findings were evaluated descriptively to identify potential hazards and areas requiring additional preventive attention. The assessment identified several potential occupational hazards across production activities, including machinery noise in the milling area, vibration near heavy equipment, thermal exposure in evaporation and cooking areas, airborne dust in packaging operations, and chemical handling in laboratory and cleaning areas. Ergonomic concerns included awkward working postures, repetitive movements, and manual handling of heavy loads, particularly in packaging and warehouse activities. The facility reported established OHS management practices, including written safety policies, hazard identification procedures, PPE provision, workplace safety signage, fire protection equipment, evacuation arrangements, first-aid facilities, and occupational medical examinations. A fitness-for-duty classification system and a seven-step occupational disease diagnostic framework were also described. However, the completeness and effectiveness of these measures could not be independently established through the available observational information. Ergonomic risk evaluation was identified as an area requiring further attention, particularly for repetitive tasks and manual material handling. This study identified multiple potential occupational hazards and documented existing workplace safety control practices in a sugar manufacturing facility. Although general OHS infrastructure and preventive procedures were reported, further assessment is needed to verify control implementation and evaluate ergonomic risks systematically. Strengthening task-specific hazard assessment, ergonomic improvements, mechanical handling support, and periodic safety evaluations may contribute to more comprehensive occupational risk management. Because occupational exposure measurements, accident records, and intervention outcomes were not available, the effectiveness of existing controls in reducing workplace accidents could not be determined.

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1. Introduction

Occupational safety and health (OSH) is an essential component of industrial risk management, particularly in manufacturing environments where workers are exposed to multiple hazards associated with machinery, production processes, workplace conditions, and organizational activities. The identification, assessment, and control of occupational risks are necessary to minimize potential injuries, prevent work-related diseases, and support sustainable industrial operations. Occupational risk assessment involves systematically identifying sources of harm,

evaluating possible consequences, and determining appropriate preventive measures. Ale et al. (2008) emphasized the importance of structured occupational risk models for understanding and quantifying potential workplace hazards, while Gul (2018) reviewed various occupational health and safety risk assessment approaches and highlighted the importance of considering multiple criteria when evaluating workplace risks. These findings demonstrate that occupational safety management should involve systematic evaluation rather than reliance exclusively on general safety procedures or the availability of protective equipment.

Manufacturing industries present particular challenges because occupational hazards may arise simultaneously from mechanical equipment, physical working conditions, chemical substances, repetitive tasks, and human–machine interactions. Industrial operations frequently involve complex production systems in which changes in equipment conditions, task demands, and worker behavior may influence occupational risk. Moatari-Kazerouni et al. (2015) developed a risk estimation tool specifically for manufacturing systems, emphasizing the need to evaluate hazardous situations associated with industrial machinery and production processes. Similarly, Tadić et al. (2012) proposed an occupational safety risk assessment model for the processing industry, demonstrating the importance of considering uncertainties and variations in hazardous working conditions. Gul and Guneri (2016) also investigated occupational safety risk assessment in the aluminum industry, illustrating the relevance of systematic risk evaluation in industrial manufacturing environments. Collectively, these studies support the application of structured hazard identification and preventive risk management in facilities where multiple occupational hazards coexist.

The sugar manufacturing industry represents a relevant occupational setting because its operations involve machinery, heating processes, material transportation, packaging, and storage activities. Workers may encounter physical hazards such as machinery noise, vibration, and elevated workplace temperatures, alongside potential exposure to airborne dust, chemical substances, and mechanical equipment. In addition, manual material handling, repetitive movements, and awkward working postures may create ergonomic concerns during packaging and warehouse operations. These hazards can vary according to the production process, equipment characteristics, job assignments, and operational arrangements. Mutlu and Altuntas (2019) developed an integrated occupational risk analysis approach for the textile industry, demonstrating how different industrial hazards can be evaluated within a structured safety management framework. Ak et al. (2022) further investigated occupational health, safety, and environmental risk assessment in textile production, emphasizing the importance of systematic evaluation in complex manufacturing operations. Although these studies were conducted in different industrial sectors, their findings provide relevant methodological perspectives for understanding multi-hazard conditions in sugar manufacturing.

Workplace hazard identification is an important initial stage of occupational risk assessment because preventive actions depend on recognizing hazardous activities and conditions. Walkthrough surveys, workplace observations, occupational safety checklists, worker interviews, and company documentation can provide preliminary information concerning existing hazards and available control measures. Saedi et al. (2014) developed a Hazard Identification, Risk Assessment, and Risk Control (HIRARC) model for a hydroelectric power generation plant, incorporating workplace inspection, hazard checklists, task observation, interviews, and risk evaluation. Their study demonstrated the value of combining different information sources to identify occupational hazards and prioritize preventive actions. Similarly, Marhavilas et al. (2011) reviewed occupational risk assessment methodologies and classified commonly used approaches into qualitative, quantitative, and hybrid categories. These findings indicate that descriptive workplace observations can contribute to preliminary hazard identification, although their capacity to establish risk severity or control effectiveness is limited when quantitative exposure measurements and standardized assessment procedures are unavailable.

Occupational injury prevention also requires consideration of the likelihood and potential severity of hazardous events. Hazards associated with industrial machinery, equipment operation, electrical systems, and material handling may result in different consequences depending on exposure conditions, safety barriers, and organizational practices. Azadeh-Fard et al. (2015) developed an occupational injury risk assessment approach incorporating accident severity and preventability, demonstrating the value of injury-related information in understanding occupational risk. Ersoy (2015) examined occupational accident risk analysis in a marble factory, providing an industrial case study relevant to workplace hazard identification and risk evaluation. These investigations demonstrate that comprehensive occupational safety assessment should consider both the presence of hazardous conditions and the potential consequences of exposure. Nevertheless, identifying a hazard does not establish that an occupational accident has occurred, and documenting preventive equipment does not independently demonstrate that accident incidence has been reduced.

The selection and prioritization of occupational safety controls represent another important component of workplace risk management. Preventive measures may include engineering controls, equipment safeguards, administrative procedures, workplace safety training, personal protective equipment, and periodic inspection of operational conditions. The suitability of these controls depends on the nature of the identified hazards, operational requirements, worker activities, and available organizational resources. Marhavilas et al. (2019) proposed an integrated approach combining Hazard and Operability Study (HAZOP), risk matrices, and the Analytical Hierarchy Process (AHP) to identify critical control points and prioritize industrial risks. Gul and Ak (2018) also examined approaches for quantifying occupational health and safety risk ratings, emphasizing the methodological importance of consistent risk evaluation. These studies illustrate how structured assessment frameworks can support decisions concerning preventive priorities. However, the use of such methods requires appropriate data and explicitly defined evaluation criteria. Their relevance to the present study is therefore conceptual, as the original workplace assessment did not implement quantitative risk scoring, HAZOP, AHP, or fuzzy multi-criteria analysis.

Modern occupational safety research has increasingly investigated integrated risk assessment models capable of addressing uncertainty and multiple evaluation criteria. Gul et al. (2021) developed a Fermatean fuzzy TOPSIS-based approach for occupational risk assessment in manufacturing, illustrating how systematic decision-making frameworks can support the prioritization of industrial hazards. These approaches may be useful when organizations possess sufficient information to evaluate risk probability, severity, exposure characteristics, and preventive control performance. Nevertheless, advanced quantitative models cannot replace the need for reliable workplace observations, documented evidence, and appropriate occupational exposure information. Consequently, preliminary observational assessments remain important for identifying potential hazards and determining where more detailed technical or quantitative investigations may be required.

Occupational safety management systems provide an organizational framework for integrating hazard identification, risk management, preventive controls, worker participation, and continuous improvement. ISO 45001:2018 establishes internationally recognized requirements for occupational health and safety management systems, including leadership commitment, risk-based planning, operational control, performance evaluation, and continual improvement (International Organization for Standardization [ISO], 2018). However, the existence of

written safety policies, protective equipment, or reported management-system certification should not automatically be interpreted as evidence of full regulatory compliance or effective occupational accident prevention. Such conclusions require supporting documentation, systematic evaluation, and appropriate safety performance indicators. In this context, workplace observations can provide useful preliminary evidence regarding the availability and implementation of occupational safety measures while identifying areas where further verification is necessary.

The present study was conducted at a sugar manufacturing facility identified as PT X in Lampung, Indonesia, using a descriptive observational approach through a workplace walkthrough survey on May 7, 2026. The original assessment identified potential occupational hazards involving machinery noise, vibration, heat exposure, airborne dust, chemical handling, repetitive movements, awkward working postures, and manual material handling. The facility also reported existing occupational safety practices, including written safety policies, personal protective equipment, emergency response arrangements, workplace safety procedures, and occupational medical examinations. However, the available documentation did not include quantitative exposure measurements, standardized ergonomic assessment scores, complete verification of control implementation, or occupational accident data sufficient to demonstrate preventive effectiveness. Accordingly, this study aims to identify potential occupational hazards and describe existing workplace safety control practices in a sugar manufacturing facility in Lampung, Indonesia. Particular attention is given to multi-hazard identification, the documentation of preventive measures, and ergonomic concerns associated with production, packaging, and warehouse activities. The findings are expected to provide a descriptive basis for identifying occupational safety improvement priorities and supporting more systematic workplace risk assessment.

2. Materials and Methods

2.1. Study Design and Occupational Setting

This study employed a descriptive observational design using a workplace walkthrough survey to identify potential occupational hazards and assess existing workplace safety control practices at a sugar manufacturing facility, designated as PT X, in Lampung, Indonesia. The assessment was conducted on May 7, 2026, as part of an occupational medicine field activity involving observation of workplace conditions, identification of potential occupational risks, and examination of occupational safety and health (OSH) management practices. The study was intended to provide a descriptive understanding of the relationship between industrial operations, potential workplace hazards, and reported preventive measures, rather than to determine occupational accident incidence or establish the effectiveness of specific safety interventions. A descriptive observational approach was selected because the available information primarily consisted of workplace observations, occupational safety checklist findings, brief interviews, and company documentation. Such an approach can support preliminary hazard identification and the recognition of areas requiring more detailed evaluation. Marhavilas et al. (2011) classified occupational risk assessment methodologies into qualitative, quantitative, and hybrid approaches, highlighting the importance of selecting assessment procedures according to available information and study objectives. Similarly, Gul (2018) reviewed occupational safety risk assessment methodologies and emphasized that appropriate risk evaluation requires consideration of the nature of workplace hazards, assessment criteria, and available evidence.

The selected facility represented an industrial setting involving multiple production activities, including machinery operation, sugar processing, heating and evaporation, packaging, warehouse operations, and material transportation. These processes were considered relevant to occupational safety assessment because they may expose workers to mechanical, physical, chemical, ergonomic, and organizational hazards. The walkthrough assessment focused on operational locations described in the original workplace report, particularly milling, evaporation and cooking, packaging, warehouse, laboratory, and cleaning areas. The primary assessment population was defined by the workplace activities and occupational conditions encountered during the visit, rather than by a predetermined epidemiological sample. The original manuscript described the involvement of production employees and personnel responsible for Health, Safety, and Environment (HSE) activities. However, the number of workers observed or interviewed, their occupational characteristics, and participant selection procedures were not documented. Accordingly, the assessment was interpreted as an observational evaluation of workplace conditions and safety practices rather than an employee-level survey representing the entire workforce.

The study design was informed by occupational risk assessment research conducted in manufacturing and other industrial settings. Moatari-Kazerouni et al. (2015) emphasized that risk estimation in manufacturing environments requires consideration of hazardous situations arising from machinery and production processes. Tadić et al. (2012) also demonstrated the relevance of structured occupational risk evaluation in the processing industry. These studies provided a methodological rationale for examining different occupational hazards within a single industrial setting. However, their quantitative modeling procedures were not applied in the present assessment because the original workplace documentation did not contain the required probability, severity, exposure, or model-input data. The study was therefore structured as a preliminary workplace hazard identification and safety-control assessment. Its principal objectives were to describe observable or reported occupational hazards, identify existing occupational safety facilities and procedures, examine areas requiring additional verification, and develop evidence-informed recommendations for improving workplace risk management.

2.2. Workplace Walkthrough Survey and Data Collection

Data collection was conducted through direct workplace observation, an occupational health and safety checklist, brief interviews with workplace personnel, and review of available company information. The walkthrough survey served as the principal observational procedure for identifying potential hazards associated with production equipment, working conditions, material handling, occupational hygiene, and safety infrastructure. The observation process considered the major operational activities described in the workplace report, including milling, thermal processing, packaging, storage, and associated support operations. Physical hazards were examined through observation of machinery-related noise, vibration, potentially hot working conditions, and environmental characteristics that could influence worker safety. Mechanical hazards were considered in relation to operating equipment, moving machinery, and the presence of protective arrangements. Chemical and airborne particulate hazards were considered in locations where dust generation, chemical storage, cleaning activities, or laboratory operations were reported.

Ergonomic factors were evaluated descriptively by identifying activities potentially involving awkward body positions, repetitive movements, prolonged standing, manual material handling, and physically demanding tasks. Particular attention was directed toward packaging and warehouse activities because the original report described repeated lifting and transportation of sugar sacks. These activities were considered potential sources of biomechanical loading and musculoskeletal strain. However, the survey did not report measurements of lifting frequency, handled load mass, movement duration, joint angles, or other task-specific ergonomic variables. The observational approach was conceptually informed by hazard identification, risk assessment, and risk control principles. Saedi et al. (2014) demonstrated the application of a HIRARC framework incorporating workplace inspection, task observation, interviews, and hazard assessment in an industrial power generation setting. The relevance of this approach to the present study lies in the systematic identification of hazardous conditions and associated preventive measures. Nevertheless, a complete HIRARC analysis, including quantified likelihood, severity, and risk classification, was not documented in the original assessment.

The occupational safety checklist covered 20 areas of workplace safety management. These included written occupational safety policies, hazard identification and risk assessment procedures, personal protective equipment, machinery condition, electrical installations, fire protection, evacuation arrangements, housekeeping, ergonomic practices, chemical handling, ventilation and air quality, noise control, workplace thermal conditions, lighting, employee medical examinations, occupational safety training, accident reporting, first aid and medical facilities, environmental monitoring, and safety audits. These checklist domains were considered relevant to comprehensive occupational safety management because they represent different sources of risk and components of organizational prevention. The interpretation of checklist information was informed by research emphasizing structured occupational risk estimation and evaluation of preventive controls in industrial systems (Ale et al., 2008; Gul & Ak, 2018).

During the walkthrough survey, available safety infrastructure and workplace arrangements were examined descriptively. The original manuscript reported personal protective equipment such as helmets, protective footwear, gloves, masks, hearing protection, and safety glasses. Collective safety provisions included fire extinguishers, evacuation routes, assembly points, emergency signage, and first aid facilities. These findings were recorded as information on existing or reported safety arrangements, rather than evidence that the controls achieved a specified level of risk reduction. Brief interviews with workplace personnel and HSE representatives were used to obtain supplementary information about occupational safety policies, workplace hazards, preventive procedures, and employee health management. The original manuscript did not report the exact number of interviews, interview duration, standardized interview questions, or recording and transcription procedures. Therefore, interview information was used descriptively without assuming the application of a formal qualitative interview protocol or a complete thematic analysis.

Company information was also used to describe the occupational health surveillance framework, including pre-employment, periodic, and special medical examinations. The original report identified five fitness-for-duty categories: Fit to Work, Fit with Notes, Fit with Restrictions, Temporarily Unfit, and Permanently Unfit. A seven-step occupational disease diagnosis framework was also described. These components were included as organizational occupational health practices, although individual medical examination results and the number of workers assigned to each fitness category were not available. No quantitative measurements of occupational noise, vibration, workplace thermal conditions, airborne dust concentrations, or chemical exposures were presented in the original data. Likewise, no standardized ergonomic assessment scores or worker-level occupational injury outcomes were available. Consequently, potential occupational hazards were identified from observations and reported workplace characteristics, without determining exposure-limit compliance or clinically confirmed occupational disease prevalence.

2.3. Descriptive Analysis, Safety-Control Evaluation, and Reporting Limitations

The collected information was evaluated descriptively to identify potential occupational hazards, characterize available workplace safety measures, and recognize areas where additional risk assessment or preventive control verification may be necessary. The evaluation was organized according to the principal hazard categories identified during the survey and the occupational safety management components recorded in the original checklist. Potential workplace hazards were grouped into physical, mechanical, chemical or particulate, ergonomic, and organizational categories. Physical hazards included noise, vibration, and thermal exposure associated with industrial production equipment. Mechanical hazards were associated with machinery operation and material handling. Chemical and particulate hazards included reported dust-generating activities and chemical use in laboratory and cleaning operations. Ergonomic hazards included repetitive movements, awkward working positions, and manual lifting activities. Organizational considerations included safety procedures, training, production demands, medical surveillance, and accident reporting arrangements.

The evaluation framework distinguished between the identification of potentially hazardous conditions and the assessment of actual occupational risk. Hazard identification was based on observable or reported workplace characteristics, whereas quantitative risk estimation would require additional information regarding exposure frequency, probability of harmful events, severity of potential consequences, and the effectiveness of existing preventive controls. Ale et al. (2008) emphasized the importance of systematic occupational risk modeling, while Moatari-Kazerouni et al. (2015) demonstrated that manufacturing risk estimation requires clearly defined hazardous scenarios and assessment criteria. The present analysis did not calculate numerical risk ratings, occupational exposure indices, or accident probabilities. Likewise, formal multi-criteria decision-making, fuzzy modeling, Failure Mode and Effects Analysis, and quantitative prioritization techniques were not performed. Although such approaches have been described in industrial occupational safety research, including Gul and Guneri (2016) and Mutlu and Altuntas (2019), the available workplace information was insufficient to support their application retrospectively.

Existing workplace safety measures were considered according to their reported purpose and the evidence available in the original assessment. These included organizational policies, preventive operating procedures, machinery safeguards, personal protective equipment, emergency response facilities, employee health services, and workplace inspection activities. The presence of a particular control was distinguished from verified compliance with technical or regulatory requirements and from demonstrated effectiveness in reducing occupational accidents. This distinction was important because the original workplace checklist marked all 20 occupational safety aspects with check symbols, while the accompanying discussion identified deficiencies in ergonomic risk evaluation. Therefore, the checkmarks could not

independently establish full compliance or control effectiveness. The revised analytical interpretation treated these marks as checklist records requiring confirmation of their meaning, supporting evidence, and verification criteria.

In particular, ergonomic risk was interpreted as an improvement priority because the original survey identified manual handling and repetitive activities in packaging and warehouse operations without presenting standardized ergonomic assessments. The need for additional evaluation was supported conceptually by occupational risk assessment literature addressing industrial hazards and the importance of appropriate control prioritization (Gul & Ak, 2018; Marhavilas et al., 2011). Preventive recommendations were developed from the identified workplace hazards and apparent limitations in available safety-control information. These recommendations included further assessment of manual material handling, evaluation of machinery-related hazards, improved verification of safety-control implementation, and more systematic documentation of occupational exposure and incident information. Proposed measures were considered recommendations arising from the assessment rather than interventions implemented and evaluated during the field visit.

The descriptive results were not subjected to inferential statistical testing because the original documentation did not contain an individual-level analytical dataset, quantitative exposure measurements, or occupational accident records suitable for statistical comparison. Likewise, the study did not undertake a formal safety audit capable of establishing comprehensive regulatory compliance or ISO 45001 certification status. Several methodological limitations were considered when interpreting the findings. First, the survey was conducted on a single documented date, limiting assessment of variability across production cycles, shift schedules, maintenance activities, and operating conditions. Second, the original manuscript did not provide the number and selection of participating workers or the duration of workplace observations. Third, the safety checklist lacked documented scoring criteria and supporting verification records for all assessed controls.

Fourth, the absence of objective occupational exposure measurements prevented quantitative assessment of physical, chemical, and ergonomic risk levels. Fifth, actual workplace accident frequencies, incident severity indicators, near-miss records, and comparative safety performance data were not provided. Consequently, the study could not determine whether existing safety measures reduced occupational accident incidence. Finally, the original manuscript did not specify formal ethics review procedures, interview consent arrangements, or institutional approval for the publication of company-derived information. These details should be confirmed by the authors before submission. The facility was identified as PT X to maintain organizational anonymity, and no individually identifiable worker information was included in the reported findings. Accordingly, the present study should be interpreted as a descriptive workplace hazard identification and safety-control assessment that provides preliminary information for occupational risk management. Its findings support the identification of potential hazards and areas requiring further evaluation but do not establish quantitative risk levels, verified regulatory compliance, or the effectiveness of existing measures in preventing workplace accidents.

3. Results and Discussion

3.1. Workplace Characteristics and Occupational Hazard Identification

The workplace walkthrough survey conducted at PT X Lampung on May 7, 2026, identified several potential occupational hazards associated with sugar manufacturing operations. The observed and reported industrial activities included milling, thermal processing, packaging, warehouse operations, laboratory activities, and equipment cleaning. These operations involved machinery, elevated-temperature processes, material handling, and workplace activities that could generate physical, mechanical, chemical, ergonomic, and organizational hazards. The findings demonstrated the presence of multiple potential sources of occupational exposure within the same industrial facility, although the assessment did not establish their quantitative severity or associated injury incidence. Physical hazards were identified primarily in production areas. Machinery-related noise was reported in the milling unit, where continuous equipment operation represented a potential source of occupational noise exposure. Vibration was also identified around heavy production machinery, including vibration transmitted through the surrounding floor. In the evaporation and cooking areas, heat-generating industrial processes were associated with potentially elevated thermal exposure. These conditions were identified through the walkthrough assessment rather than standardized occupational hygiene measurements. Consequently, the findings indicate potential exposure sources but do not establish whether workplace noise, vibration, or thermal conditions exceeded applicable occupational exposure limits.

Potential chemical and airborne particulate hazards were reported in packaging, laboratory, and cleaning areas. The original assessment described fine dust in the packaging area and referred to both bagasse and sugar dust. However, the actual particulate composition was not analytically determined. These terms should therefore be interpreted cautiously because fibrous sugarcane residue and sugar particles represent different materials with potentially different exposure characteristics. The presence of chemical handling activities in laboratory and cleaning operations also indicated a need to consider chemical storage, labeling, handling procedures, and potential exposure pathways. No quantitative airborne particulate measurements, chemical concentration data, or biological exposure indicators were available. Mechanical safety concerns were associated with equipment operation and material transportation. Sugar manufacturing involves machinery and moving mechanical components that may create contact, entanglement, crushing, or impact hazards when protective measures are inadequate. However, the walkthrough report did not document specific machinery defects, missing guards, or recorded mechanical injuries. Accordingly, machinery-related hazards were considered inherent or potential operational concerns rather than confirmed failures of equipment safety systems.

Ergonomic hazards were particularly apparent in packaging and warehouse activities, where the original assessment described manual lifting, transportation of sugar sacks, repetitive movements, and awkward working postures. Repeated material handling may impose physical demands on the trunk, shoulders, and upper extremities, depending on handled load characteristics, movement frequency, working posture, and task duration. However, the original assessment did not provide quantitative measurements of these variables. Therefore, the ergonomic findings indicate tasks requiring additional evaluation rather than confirmed high-risk classifications or clinically established musculoskeletal disorders. Organizational and psychosocial considerations were also identified. The original report described production demands and workload associated with daily manufacturing targets. These operational conditions may interact with physical and ergonomic hazards through task pace, recovery opportunities, and worker attention. Nevertheless, the survey did not include validated psychosocial questionnaires, quantitative workload assessments, or worker-level indicators sufficient to establish occupational stress prevalence. Overall, the walkthrough assessment identified multiple categories of potential occupational hazards across different operational areas. The principal findings are summarized in

Table 1. The table describes workplace conditions and possible consequences without assigning numerical risk ratings or implying that occupational diseases or injuries occurred during the study period.

Table 1. Identified Occupational Hazards and Potential Health and Safety Consequences at PT X Lampung

Operational area	Potential hazard	Reported or observed condition	Potential consequence
Milling unit	Noise	Continuous operation of production machinery	Hearing-related risk
Heavy machinery area	Vibration	Floor vibration near equipment	Physical discomfort or vibration-related exposure
Evaporation and cooking	Heat	Heat-generating industrial processes	Heat strain and dehydration risk
Packaging area	Airborne dust	Fine particulate material reported	Respiratory irritation or inhalation exposure
Laboratory and cleaning	Chemical	Handling of industrial chemicals	Chemical contact or inhalation hazards
Production equipment	Mechanical	Moving industrial machinery	Contact or entanglement injury potential
Packaging and sorting	Ergonomic	Repetitive movements and awkward postures	Musculoskeletal strain
Warehouse	Ergonomic	Manual lifting and transportation of sugar sacks	Back and upper-limb loading
Production operations	Organizational	Production targets and workload demands	Potential work-related fatigue and performance effects

Source: *Descriptive synthesis of the May 7, 2026 walkthrough survey. Potential consequences are hazard-based interpretations, not documented diagnoses or incidents. Quantitative exposure and ergonomic measurements were not available*.

3.2. Existing Workplace Safety Control Practices

The workplace assessment documented a range of occupational safety arrangements intended to prevent accidents and minimize harmful workplace exposure. The original checklist addressed 20 components of occupational safety management, including management policies, hazard identification, personal protective equipment, equipment safety, electrical installations, emergency preparedness, housekeeping, ergonomics, chemical handling, environmental conditions, worker health examinations, occupational safety training, incident reporting, and internal evaluation. At the organizational level, the facility reported the existence of written occupational safety policies and a management commitment to accident prevention, occupational health protection, and environmental management. The original report described a company safety policy emphasizing a zero-accident objective, occupational disease prevention, and environmental responsibility. It also referred to ISO 45001 and other management-system certifications. However, supporting certification documents, validity information, formal audit findings, and detailed compliance records were not included in the available research materials. These statements should consequently be interpreted as company-reported management practices rather than independent verification of complete management-system compliance.

Personal protective equipment constituted a prominent component of workplace safety practice. The original report described safety helmets, protective footwear, gloves, protective masks, hearing protection, and safety glasses, with equipment use varying according to occupational activities and exposure characteristics. PPE was reported as available and used in relevant operational areas. Nevertheless, the walkthrough documentation did not include systematic observations of compliance across multiple shifts, quantitative PPE utilization records, or assessments of equipment suitability and maintenance. Therefore, the available information supports the reported presence and use of PPE but does not establish complete compliance among all employees. Collective safety and emergency response arrangements were also described. These included portable fire extinguishers, evacuation routes, assembly points, first-aid facilities, and hazard communication signs. Such arrangements are relevant because manufacturing operations may involve mechanical, electrical, thermal, and fire-related hazards that require coordinated emergency preparedness. However, the original report did not provide inspection dates, maintenance certificates, emergency drill performance, or formal emergency response audit results. The presence of emergency equipment should therefore be distinguished from independently demonstrated operational readiness.

The original checklist also included machinery protection, electrical installations, chemical control, ventilation, workplace environmental monitoring, accident reporting, and internal safety audits. These domains were marked as assessed in the original table, but the meaning of the checkmarks was not defined. In particular, the available materials did not establish whether each symbol represented an item being inspected, the existence of a preventive measure, or verified conformity with a regulatory requirement. This distinction is important because the original discussion simultaneously identified deficiencies in ergonomic risk evaluation despite the ergonomics checklist item being marked positively. Accordingly, the revised presentation treats the checklist as a record of occupational safety components addressed during the workplace assessment, not as a validated compliance score. The descriptive synthesis in **Table 2** preserves all 20 original checklist domains while identifying the type of supporting information available. Safety measures explicitly described in the accompanying narrative are distinguished from checklist items for which detailed implementation evidence was not presented. This approach allows the findings to remain faithful to the original observations while avoiding unsupported conclusions regarding comprehensive compliance or preventive effectiveness. The assessment indicated that workplace safety infrastructure and organizational procedures had been reported across several domains. However, determining their effectiveness would require verification of equipment conditions, assessment of worker exposure, observation of actual work practices, and review of safety performance information over an appropriate period. The findings therefore support the existence of a workplace safety management framework but do not establish that occupational accident risks have been fully controlled.

Table 2. Occupational Safety Control Components Recorded in the Original 20-Item Checklist

No	Control component	Available supporting information	Evidence interpretation
1	K3 policy	Written policies and commitment described	Reported existing
2	Hazard identification and risk assessment	Hazard identification described; formal risk scores absent	Partially documented
3	PPE	PPE provision and use described	Reported existing
4	Machinery and equipment	Checklist marked; no detailed inspection findings	Not independently verified
5	Electrical installation	Checklist marked; no electrical testing records	Not independently verified
6	Fire prevention	Fire extinguishers and emergency facilities described	Reported existing
7	Evacuation routes and emergency exits	Routes and assembly points described	Reported existing
8	Housekeeping	Checklist marked; no detailed inspection findings	Not independently verified
9	Work ergonomics	Manual handling concerns described; no standardized assessment	Requires further evaluation
10	Chemical control	Chemical activities identified; no exposure assessment	Requires further verification
11	Ventilation and air quality	Checklist marked; no air-quality measurements	Not independently verified
12	Noise control	Noise hazard and hearing protection described; no noise measurements	Partially documented
13	Working temperature control	Heat sources described; no thermal measurements	Requires further evaluation
14	Lighting	Checklist marked; no illuminance measurements	Not independently verified
15	Medical examinations	MCU framework described	Reported existing
16	K3 training and education	Training included in checklist; limited implementation detail	Not independently verified
17	Accident reporting	Reporting system included in checklist; no incident records presented	Not independently verified
18	First aid and medical facilities	First-aid and medical services described	Reported existing
19	Work environment supervision	Monitoring included in checklist; measurements not supplied	Not independently verified
20	K3 audit and evaluation	Audit component listed; formal audit findings absent	Not independently verified

Note: *These classifications represent the level of documentation available in the submitted manuscript, not an independently conducted audit or a new measurement of control effectiveness. All 20 items were marked with a check symbol in the original checklist, but the meaning of that symbol was not defined*.

3.3. Occupational Health Surveillance and Ergonomic Concerns

The workplace assessment described an occupational medical surveillance system incorporating pre-employment, periodic, and special medical examinations. According to the company information presented in the original report, medical examination findings were used to categorize employees according to fitness-for-duty status. Five categories were identified: Fit to Work, Fit with Notes, Fit with Restrictions, Temporarily Unfit, and Permanently Unfit. These classifications were described as part of a framework for evaluating employee health in relation to workplace responsibilities and occupational exposure. The original report also described a seven-step occupational disease diagnostic framework incorporating clinical diagnosis, occupational exposure identification, evaluation of exposure–disease relationships, assessment of exposure characteristics, consideration of individual and non-occupational factors, and determination of occupational disease status. This framework is relevant to occupational medicine because the identification of workplace hazards should be integrated with appropriate clinical evaluation when occupational diseases are suspected.

However, the available materials did not contain the number of employees undergoing medical examinations, the distribution of fitness-for-duty categories, or documented occupational disease diagnoses. The study therefore cannot establish the prevalence of occupational illness, the frequency of work restrictions, or the effectiveness of medical surveillance in preventing adverse health outcomes. The findings support only the reported existence of an occupational health surveillance framework. Ergonomic concerns constituted an important finding of the walkthrough assessment. The original report identified repetitive movements in packaging and sorting activities and manual lifting of sugar sacks in warehouse operations. Awkward working postures and repeated material handling were considered potential contributors to musculoskeletal loading. These activities may be relevant to the development of occupational musculoskeletal symptoms when the intensity, frequency, and duration of physical demands exceed individual or organizational recovery capacities.

Despite these observations, the original checklist did not provide detailed ergonomic exposure data. Specifically, the handled load masses, lifting frequencies, horizontal reaching distances, working heights, task durations, and opportunities for recovery were not documented. No standardized ergonomic assessment results or medical data linking work activities to musculoskeletal disorders were available. Consequently, it would be inappropriate to conclude that the identified tasks had already caused clinically confirmed musculoskeletal disorders. The main ergonomic finding was therefore a gap in systematic exposure evaluation rather than evidence of an established disease burden. The presence of manual material handling and repetitive tasks indicates where more detailed task-level assessments should be directed. Such assessments could help distinguish between routine physical work demands and occupational activities requiring modification.

This finding also illustrates an important limitation of generalized occupational safety checklists. Although the ergonomics component was marked in the original checklist, the accompanying narrative identified potential ergonomic risks without providing standardized evaluation results. Accordingly, a checklist item marked as present should not be interpreted as evidence that ergonomic risks have been

appropriately quantified or effectively controlled. The results suggest that occupational medical surveillance and task-specific ergonomic evaluation should be considered complementary components of occupational risk management. Medical examinations may help identify individual health conditions and fitness-for-duty considerations, whereas workplace ergonomic assessments can characterize potentially harmful work demands. Integration of these information sources may support more targeted preventive measures, provided that relevant exposure and worker health information are collected using appropriate procedures and confidentiality safeguards.

3.4. Multi-Hazard Risk Assessment and Safety Control Effectiveness

The identification of physical, mechanical, chemical, ergonomic, and organizational hazards within a single manufacturing facility highlights the importance of integrated occupational risk assessment. Workers may encounter several potential hazards during routine operations, and the consequences of exposure may depend on the interaction between equipment characteristics, task demands, work organization, and preventive measures. In this study, the coexistence of different hazard categories was established descriptively, but their relative risk magnitude and combined effects were not quantitatively evaluated. The findings are consistent with the broader occupational safety literature emphasizing the importance of considering multiple risk factors within industrial systems. Badri et al. (2012) proposed an analytical approach for integrating occupational health and safety risk factors into project risk evaluation, demonstrating the value of considering different sources of occupational risk within a coordinated assessment framework. Similarly, Papazoglou et al. (2017) developed a quantitative occupational risk model incorporating multiple hazards, individual workers, and associated work activities. Although these approaches are more analytically advanced than the present walkthrough survey, they illustrate how task-specific information can contribute to a more complete understanding of industrial occupational risk.

A distinction is also necessary between routine occupational hazards and major accident scenarios. Workplace hazards associated with machinery, electrical systems, heating equipment, and material processing may involve different mechanisms and potential consequences. Gnoni and Bragatto (2013) emphasized the importance of integrating major accident hazards into occupational risk assessment, particularly in industrial facilities where plant-level processes and worker-level activities interact. For PT X Lampung, this perspective suggests that future assessments could benefit from linking operational area characteristics, worker tasks, equipment safeguards, and emergency response arrangements. However, the present study did not perform a major accident hazard analysis or quantify accident scenario probabilities. Another important consideration concerns the relationship between documented occupational safety controls and actual workplace safety performance. The existence of PPE, written procedures, emergency equipment, or occupational health services represents an important component of prevention, but these measures do not independently establish that risk has been reduced to an acceptable level. Beriha et al. (2012) examined industrial safety performance using a fuzzy-based approach that considered relationships between safety-related investments and accident outcomes. Their research demonstrates the distinction between the provision of safety resources and the systematic evaluation of occupational safety performance. In the present study, the absence of historical accident records, injury severity data, and consistent exposure measurements prevented comparable evaluation of preventive effectiveness.

The interpretation of occupational safety checklists also requires attention to the quality of supporting evidence. A control recorded as available may not necessarily be suitable for every hazardous activity, properly maintained, consistently implemented, or sufficient to address the relevant exposure. Oliveira et al. (2018) discussed methodological challenges associated with occupational safety risk matrices and proposed decision-analytical improvements to risk evaluation. Their findings support the importance of clearly defined assessment criteria and transparent interpretation of risk information. In the present assessment, the lack of documented checklist scoring criteria was therefore a significant limitation in determining the adequacy of reported safety controls. The original report's statement that the company had successfully reduced occupational accidents cannot be verified using the available dataset. No baseline accident frequency, incident severity indicators, lost-time injury records, near-miss data, or comparable historical observations were presented. Consequently, the study cannot establish a causal or statistical relationship between existing occupational safety practices and accident prevention outcomes.

The findings instead indicate that a range of occupational safety measures was described in the facility and that additional verification is required to determine their implementation, suitability, and effectiveness. This distinction is especially relevant when interpreting formal occupational safety management arrangements. Reported management-system certification may indicate organizational adoption of established safety procedures, but the present walkthrough survey cannot substitute for a formal certification audit or comprehensive regulatory compliance evaluation. Taken together, the results support the value of preliminary workplace observations for identifying potential hazards and safety management components. However, a more comprehensive occupational risk evaluation would require standardized assessment criteria, task-specific exposure information, verification of preventive controls, and longitudinal accident records. These additional data would allow industrial safety management to move beyond descriptive hazard identification toward evidence-based evaluation of preventive performance.

3.5. Ergonomic Risk Management and Preventive Priorities

Ergonomic risks associated with manual material handling and repetitive work emerged as a prominent area requiring further assessment. The original survey reported that packaging and warehouse employees performed activities involving repetitive movements, awkward working postures, and the lifting or transportation of sugar sacks. These conditions may impose biomechanical demands on workers, particularly when tasks require repeated trunk flexion, extended reaching, frequent lifting, or prolonged handling activities. The relevance of these findings extends beyond the physical characteristics of individual tasks. Ergonomic exposure may also be influenced by production schedules, equipment layout, available handling devices, task organization, and worker experience. Consequently, preventive planning should consider both workstation-level hazards and the organizational factors affecting occupational exposure.

La Fata et al. (2021) examined occupational risk prioritization using a multi-criteria framework incorporating human factors. Their research highlights the importance of accounting for human performance and task characteristics in occupational safety decisions. In the context of PT X Lampung, this perspective supports further investigation of how production demands, repeated manual handling, and workplace arrangements may influence ergonomic exposure. However, the present assessment did not collect sufficient data to establish specific human error probabilities or quantitative ergonomic risk ratings. The identification of ergonomic hazards should be followed by systematic task evaluation. Such evaluation may include documenting load characteristics, lifting frequency, task duration, workstation layout, movement

patterns, and the availability of mechanical handling equipment. These data would support the selection of appropriate assessment procedures and provide a more reliable basis for determining whether preventive modifications are necessary.

The original manuscript recommended mechanical handling aids, improvements in working posture, workstation modifications, and more dynamic job rotations. These recommendations are relevant to the identified ergonomic concerns, but their effectiveness was not tested during the study. Consequently, they should be presented as proposed preventive measures rather than interventions already demonstrated to reduce occupational injury risk. Mechanical handling equipment may reduce certain physical demands when appropriately selected and integrated into existing operations. Workstation modifications may also reduce awkward postures or unnecessary material transportation. Administrative measures, including task organization, worker instruction, and appropriate recovery opportunities, may provide additional support. However, administrative arrangements such as job rotation should not be assumed to reduce total exposure unless the alternative tasks produce sufficiently different physical demands.

A further consideration is the need to prioritize preventive measures based on the nature of identified hazards and the reliability of available evidence. Abas et al. (2021) developed a risk assessment approach based on damaging energy and argumentation theory to evaluate occupational safety risks in construction activities. Although the study was undertaken in a different industrial sector, its emphasis on structured reasoning about hazardous energy provides a relevant conceptual perspective for assessing machinery operation, material handling, and other energy-related hazards in manufacturing. Similarly, Kokangul et al. (2017) investigated occupational risk assessment using the Analytical Hierarchy Process and Fine-Kinney methodologies, illustrating how occupational hazards may be prioritized when sufficient assessment information and historical safety data are available. The present study did not apply these methods, but their underlying emphasis on systematic prioritization supports the recommendation that future evaluations should progress from descriptive identification toward more structured risk assessment.

The findings also suggest that risk control planning should recognize interactions between hazards and preventive measures. Cinar and Cebi (2022) proposed a framework for assessing occupational risks and hazard prevention that considers relationships among workplace activities and preventive decisions. This perspective is relevant to manufacturing settings where changes in equipment operation, workstation arrangement, or job organization may influence several hazard categories simultaneously. For PT X Lampung, the most immediately identifiable opportunities for further investigation concern manual material handling in warehouse operations, repetitive work in packaging and sorting, and the adequacy of existing controls for machinery, heat, noise, and airborne particulate exposure. However, these areas should be regarded as priorities for additional assessment rather than a numerically ranked hierarchy of occupational risks. The proposed preventive priorities are summarized in **Table 3**. These recommendations are derived from the identified workplace conditions and relevant occupational safety literature. They were not implemented or evaluated as part of the original observational study.

Table 3. Recommended Priorities for Further Occupational Risk Assessment and Preventive Control Evaluation

Occupational concern	Identified evidence gap	Recommended follow-up
Machinery safety	Detailed guard inspection data unavailable	Verify safeguards, maintenance records, and task procedures
Noise	No measured exposure levels	Conduct occupational noise monitoring
Heat exposure	No quantitative thermal assessment	Evaluate conditions near heat-generating processes
Dust and chemicals	Material identity and exposure levels unverified	Characterize particulates and review chemical controls
Manual handling	No load, frequency, or posture measurements	Perform task-specific ergonomic evaluation
PPE implementation	No systematic compliance observations	Verify selection, suitability, condition, and actual use
Emergency preparedness	No documented drill or maintenance outcomes	Review equipment inspection and emergency response records
Medical surveillance	No employee-level outcome summary	Evaluate aggregate health findings while protecting confidentiality
Accident prevention	No accident or near-miss dataset	Establish standardized incident reporting and trend analysis
SMK3 evaluation	No independently reviewed compliance evidence	Conduct documented internal assessment against applicable criteria

Note: *These are proposed follow-up activities, not interventions performed or evaluated in the original study. Their ordering does not indicate measured risk severity or a formal priority ranking*.

3.6. Occupational Safety Implications, Study Limitations, and Future Directions

The findings provide a descriptive overview of potential occupational hazards and reported safety control practices in a sugar manufacturing facility. The study identified multiple sources of occupational exposure across production and support activities, together with organizational arrangements intended to support occupational safety and employee health. The main contribution of the assessment lies in documenting these hazards and highlighting the need to distinguish between the existence of preventive measures and evidence demonstrating their adequacy. This distinction is particularly relevant to occupational safety management because industrial hazards are not static. Variations in operating conditions, maintenance activities, equipment performance, workload, and workforce arrangements may alter occupational exposure and the suitability of existing controls. Therefore, routine safety inspections and documentation should be supported by systematic verification of workplace conditions and preventive measures.

Santos et al. (2018) developed a failure-mapping approach for occupational safety management, demonstrating how analysis of work processes and potential failures can inform preventive planning. Although their investigation concerned a different industry, the broader principle of identifying critical process activities and possible failures is relevant to manufacturing operations. In PT X Lampung, future occupational risk assessments could benefit from integrating workplace observations, equipment inspection records, incident documentation,

and task-level evaluations to establish a more comprehensive understanding of occupational hazards. The interpretation of the present findings is subject to several limitations. First, the walkthrough survey was conducted on a single documented date, May 7, 2026. The study therefore could not capture variations in workplace conditions across different shifts, production cycles, maintenance activities, or seasonal environmental conditions. Second, the original documentation did not specify the number of workers or HSE personnel interviewed, the duration of the observations, or the procedures used to select participants. These omissions limit the ability to determine the representativeness and reproducibility of the assessment. Third, the study did not provide quantitative measurements of occupational noise, vibration, thermal exposure, airborne particulate concentrations, chemical exposures, or ergonomic workload. As a result, the assessment could not establish occupational exposure levels, confirm compliance with exposure limits, or determine the quantitative severity of the identified hazards. Fourth, the original occupational safety checklist included 20 positively marked components without providing detailed criteria for interpretation. Therefore, the checklist could not be used to calculate a validated compliance percentage or demonstrate that all preventive measures were adequate. Fifth, occupational accident records, near-miss reports, injury severity data, and historical comparisons were not available. Consequently, the study could not establish the effectiveness of existing occupational safety measures in reducing accidents or work-related diseases. Finally, the absence of documented individual medical findings prevented analysis of associations between workplace exposures, fitness-for-duty classifications, and occupational health outcomes. The study also lacked sufficient information to evaluate employee-level behavioral and psychosocial characteristics.

Future studies should incorporate repeated workplace observations across operational periods, systematic employee and HSE interviews, standardized occupational exposure measurements, and task-specific ergonomic assessments. Additional investigation should also consider the condition and effectiveness of machinery safeguards, the reliability of emergency response arrangements, and the adequacy of hazard communication and training procedures. The systematic collection of occupational accident and near-miss records would provide an additional basis for evaluating preventive performance. Such information could be integrated with documented exposure characteristics and control measures to support more comprehensive occupational risk assessment and monitoring. Overall, the present study identifies a range of potential workplace hazards and describes existing occupational safety arrangements within a sugar manufacturing facility. The findings support the need for improved verification of preventive controls, additional ergonomic evaluation, and more systematic occupational risk documentation. These improvements may strengthen future safety management decisions, although their effectiveness in reducing occupational accidents must be established through subsequent evaluation rather than inferred from the present descriptive assessment.

4. Conclusions

This descriptive observational study identified multiple potential occupational hazards and documented existing workplace safety control practices at a sugar manufacturing facility in Lampung, Indonesia. The workplace walkthrough survey revealed physical hazards associated with machinery noise, vibration, and thermal exposure; potential airborne particulate and chemical hazards; and ergonomic concerns involving repetitive movements, awkward working postures, and manual material handling, particularly in packaging and warehouse operations. The facility reported several occupational safety and health management practices, including written safety policies, personal protective equipment, emergency preparedness facilities, hazard communication, occupational medical examinations, and fitness-for-duty procedures. However, the available evidence was insufficient to establish the adequacy, consistent implementation, or effectiveness of these measures in preventing occupational accidents. Important assessment gaps included the absence of quantitative occupational exposure measurements, standardized ergonomic evaluations, clearly defined safety checklist criteria, and documented occupational accident records. The findings particularly highlight the need for more systematic ergonomic risk assessment and verification of existing preventive controls. Strengthening task-specific hazard identification, machinery safety inspections, environmental exposure monitoring, mechanical handling arrangements, employee safety education, and occupational incident documentation may support more comprehensive workplace risk management. Nevertheless, the single-day observational design and limited availability of quantitative and employee-level data prevent conclusions regarding actual occupational risk severity, regulatory compliance, or reductions in workplace accident incidence. Future investigations should incorporate repeated workplace assessments, standardized occupational risk evaluation methods, and longitudinal safety performance monitoring to determine the effectiveness of preventive interventions. Overall, this study provides a preliminary evidence base for identifying occupational safety improvement priorities and supporting the development of more systematic hazard prevention strategies in sugar manufacturing environments.

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