

Assessment of Occupational Hazards and Risks Using the HIRARC Approach in a Hospital Laundry Unit in Kudus, Indonesia

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ABSTRACT

Introduction: The laundry department in a hospital is one of the important support units of the hospital where workers are exposed to various physical, chemical, biological and ergonomic hazards.

Objectives: This study aimed to identify work site hazards, assess the level of occupational risks, and propose control measures in the laundry unit of a hospital using the Hazard Identification, Risk Assessment, and Risk Control (HIRARC) approach.

Method: This study employed a qualitative approach involving ten informants representing all laundry operational stages. Data were collected through observation, interviews, and document review, then analyzed using the risk assessment formula $R = L \times S$. The resulting scores were used to categorize and evaluate the risk levels for each operational process.

Results: The analysis revealed that most activities in the laundry unit were classified as medium risk, including exposure to microorganisms, ergonomic strain, chemical irritation, and contact with heat surfaces. Two activities machine extraction and machine cleaning were categorized as high risk due to potential mechanical entrapment and electrical shock hazards.

Conclusion: The findings emphasize the need for safety training, proper use of personal protective equipment (PPE), periodic equipment maintenance, and ergonomic improvements to reduce work site hazards. The HIRARC method proved effective in systematically identifying, evaluating, and prioritizing risk controls in hospital support services.

Keywords: HIRARC, hospital laundry, occupational safety, risk assessment, ergonomics

INTRODUCTION

Hospital support services, including the laundry department, play a crucial role in keeping hygiene norms, infection control, and operational efficiency within healthcare facilities. Laundry workers are frequently exposed to multiple occupational hazards biological, chemical, physical, mechanical, and ergonomic due to continuous contact with contaminated linen, hot machinery, detergents, and repetitive manual handling tasks. The Health and Safety Authority emphasizes that hospital laundry areas pose substantial risks such as exposure to infectious agents, chemical irritants, heat, and mechanical injury if safety controls are inadequate (Authority, 2023). Hospital support services, including the laundry department, play a crucial role in keeping hygiene norms, infection control, and operational efficiency within healthcare facilities. Laundry services are essential in ensuring the continuous availability of clean and hygienic textiles, which directly contribute to preventing healthcare-associated infections (HAIs).

Contaminated linens in healthcare settings can harbor high concentrations of microorganisms, including bacteria, viruses, fungi, and parasites originating from blood, body fluids, and patient excretions, making them a potential source of pathogen transmission if not properly managed (Centers for Disease Control and Prevention (CDC), 2024). Laundry workers are frequently exposed to multiple occupational hazards biological, chemical, physical, mechanical, and ergonomic due to continuous contact with contaminated linen, hot machinery, detergents, and repetitive manual handling tasks. Biological hazards include exposure to bloodborne pathogens such as hepatitis B, hepatitis C, and HIV through improperly handled contaminated textiles (OSHA, 2023).

Chemical hazards arise from the use of detergents, disinfectants, and other cleaning agents that may cause skin irritation, allergic reactions, or respiratory problems when exposure is not adequately controlled (OSHA, 2023). In addition, physical and mechanical hazards are commonly present in hospital laundry units, including exposure to heat, noise, and injuries from machinery such as washers, dryers, and pressing equipment. Workers are also at risk of slips, trips, and falls due to wet floors, as well as injuries from sharps inadvertently left in soiled linens (Omoijiade, Emmanuel Nosa, & Evbuomwan, 2019). Ergonomic hazards, particularly repetitive movements, prolonged standing, and manual lifting of heavy linen loads, contribute significantly to musculoskeletal disorders among laundry personnel.

The Health and Safety Authority emphasizes that hospital laundry areas pose substantial risks such as exposure to infectious agents, chemical irritants, heat, and mechanical injury if safety controls are inadequate. Therefore, implementing comprehensive occupational health and safety measures including the use of personal protective equipment (PPE), proper segregation and handling of contaminated linen, engineering controls, and worker training is essential to minimize risks and ensure a safe working environment. Furthermore, adherence to standard precautions and proper workflow design, such as minimizing agitation of contaminated textiles and ensuring appropriate containment during transport, has been shown to effectively reduce the risk of infection transmission in healthcare laundry processes (Centers for Disease Control and Prevention (CDC), 2024).

Recent studies have highlighted the physical and ergonomic strain among hospital laundry personnel. For instance, a 2022 study on public hospital laundry workers in Kupang City, Indonesia, revealed a significant relationship between workload, duration of work, environmental temperature, and the prevalence of musculoskeletal disorders (Saingo et al., 2022). Similar findings were reported in Benha City, Egypt, where laundry employees experienced chemical irritation, back pain, and burns due to prolonged exposure to detergents and steam during washing and ironing activities (El-Sayed et al., 2023). Recent studies have continued to emphasize the significant physical and ergonomic strain faced by hospital laundry personnel, with many workers reporting chronic musculoskeletal disorders and chemical-related health issues. In addition to the findings from Kupang City, Indonesia (2022), a similar study in the United States observed that laundry workers in healthcare facilities often experience musculoskeletal pain due to repetitive tasks such as lifting heavy linen and bending over washing machines for extended periods (Lee, M. K., Park, H. S., & Choi, 2021). Furthermore, a study

in Germany highlighted the negative impact of improper ergonomic setups in laundry departments, where workers reported a high incidence of lower back pain and neck strain, attributed to poor posture and prolonged standing (Schultz, T., Hermann, W., & Hoffmann, 2020). Moreover, chemical exposure continues to pose a significant risk to laundry workers. In a study conducted in Iran, healthcare laundry workers experienced skin irritation and respiratory issues as a result of long-term exposure to harsh chemicals like detergents and disinfectants commonly used in hospital laundry facilities (Rahimi, M., Riahi, M., & Soltani, 2021). This finding is echoed by research from India, which reported that laundry workers handling industrial-strength detergents without adequate protective equipment are at high risk for chemical burns and dermatitis (Sharma, P., Kumar, A., & Singh, 2022). Additionally, ergonomics experts have suggested that improving workstation design and providing proper protective gear could reduce both physical strain and exposure to harmful chemicals. Recent research in Japan advocates for the implementation of mechanized systems to reduce manual handling and enhance worker safety in healthcare laundry departments (Kato, Y., Saito, T., & Nakamura, 2023). These studies underscore the importance of improving both working conditions and protective measures for laundry workers to mitigate the physical and chemical health risks they face in healthcare environments.

Given the diverse risks present, a structured and systematic framework such as Hazard Identification, Risk Assessment, and Risk Control (HIRARC) is essential to evaluate and mitigate hazards effectively. The HIRARC method allows for the identification of potential hazards, assessment of their severity and likelihood, and formulation of prioritized control measures. This approach has been increasingly applied in healthcare settings to improve work site safety and ensure compliance with occupational health norms. A recent study in Tomohon, Indonesia, demonstrated the usefulness of HIRARC in mapping risk levels within the hospital laundry unit, identifying electrical shocks and mechanical entrapment as high-risk categories (Elshaday Natalia Moningga et al., 2025). Recent studies indicate that HIRARC is effective in systematically identifying hazards and categorizing risks into low, medium, and high levels, allowing organizations to prioritize appropriate control strategies based on severity and likelihood (Maulana, D., Waluya, A. I., 2024). The application of HIRARC across various sectors, including construction, manufacturing, and healthcare, has proven capable of reducing work site accidents through a combination of engineering controls, administrative measures, and the use of personal protective equipment (Permana, M. A., Witjaksana, B., & Purnama, 2025). However, its effectiveness is highly dependent on worker compliance, safety culture, and organizational commitment (Arlin, S. A., Tarman, T., & Wibowo, 2025). In many cases, unsafe behavior and lack of adherence to procedures remain dominant contributors to occupational incidents (Anjani, S., & Ismiyah, 2025).

To address these limitations, the integration of behavioral approaches such as the Antecedents–Situation–Action (ASA) model is recommended. The ASA model explains that worker actions are influenced by antecedent factors (e.g., training, supervision, and safety policies) and situational conditions (e.g., workload, environmental factors, and equipment design), which ultimately determine whether actions are safe or unsafe. Studies emphasize that human factors significantly influence occupational accident occurrence, particularly in high-risk work environments (Kathayat, A., Baharudin, M. R., Lee, W. W. S., & Mohd Tohir, 2025). Therefore, combining HIRARC with ASA provides a more comprehensive risk management framework by not only identifying hazards but also understanding the behavioral causes behind unsafe actions. This integrated approach enables organizations to implement more effective and sustainable control measures, including behavior-based safety programs, improved supervision, and reinforcement of safety culture. Consequently, the combination of HIRARC and ASA enhances the effectiveness of occupational health and safety management systems, particularly in complex environments such as healthcare facilities.

However, research integrating all stages of laundry operations from linen collection to distribution using a comprehensive risk assessment approach remains limited, particularly in Indonesia. Most local studies focus on single aspects such as the use of personal protective equipment (PPE) without fully examining the overall hazard chain (Desysaputri et al., 2023). Furthermore,

inadequate ergonomic design and inconsistent implementation of safety training further exacerbate occupational risks among laundry workers (Febiana & Khotimah, 2023).

Therefore, this study aims to identify occupational hazards, assess risk levels, and propose effective control measures in the hospital laundry unit using the HIRARC framework. The findings are expected to contribute to the improvement of occupational health and safety (OHS) management systems in hospital support services and fill the existing research gap on risk-based analysis in Indonesian healthcare facilities.

MATERIALS AND METHODS

Study Design

This research employed a descriptive monitoring design using the Hazard Identification, Risk Assessment, and Risk Control (HIRARC) approach to evaluate occupational hazards in the hospital laundry unit. The HIRARC method was selected due to its systematic process in identifying potential hazards, assessing their associated risks, and determining appropriate control measures in accordance with ISO 45001:2018 and Malaysian Department of Occupational Safety and Health (DOSH, 2017) guidelines.

Study Site and Period

The study was conducted in the laundry unit of a public hospital located in Central Java, Indonesia, which operates 24 hours daily and handles an average of 200–250 kg of linen per day. Data collection was carried out over a one-month period in May 2024 through field monitoring and worker interviews.

Participants

A total of 10 respondents were included in this study, representing all major activities within the laundry unit: linen reception, washing, drying, ironing, folding, storage, and distribution. Participants were selected using total sampling to ensure comprehensive coverage of all work stages. All participants had at least one year of experience in their current positions and were directly involved in operational activities.

Data Collection Procedure

Primary data were collected through:

1. Direct monitoring, documenting work processes, physical layout, and equipment use.
2. Semi-structured interviews, focusing on perceived hazards, work duration, and safety practices
3. Review of hospital documents, including standard operating procedures (SOPs), accident reports, and maintenance records.

Secondary data such as institutional safety policies and previous inspection reports were also reviewed to support contextual analysis.

Hazard Identification

Hazards were identified across all stages of the laundry process and categorized into five groups: physical, chemical, biological, ergonomic, and mechanical hazards. Each activity was observed to determine potential sources of harm, exposed body parts, and possible health effects.

Risk Assessment

The level of risk was quantified using the standard HIRARC formula:

$$R = L \times S$$

where R is the risk value, L (Likelihood) represents the probability of occurrence, and S (Severity) denotes the level of impact or injury severity. Likelihood and severity scores ranged from 1 (lowest) to 5 (highest).

Risk categories were determined based on the resulting value:

1–5: Low risk

6–10: Medium risk

>10: High risk

Risk Control

For each identified hazard, feasible control measures were proposed following the hierarchy of controls principle—elimination, substitution, engineering control, administrative control, and personal protective equipment (PPE). Recommendations were developed based on observed work conditions and interviews with supervisors.

Data Analysis

All data were tabulated and analyzed descriptively using Microsoft Excel. Frequency distributions and risk matrices were generated to illustrate hazard prevalence and corresponding risk levels. The results were validated through triangulation, comparing findings from monitoring, interviews, and document analysis to ensure reliability and internal validity.

RESULTS

Overview of Identified Hazards

The study identified ten main work activities in the hospital laundry unit, each presenting specific occupational hazards categorized into biological, ergonomic, chemical, mechanical, physical, and electrical risks. Based on field monitorings and worker responses, a total of ten hazard points were analyzed using the HIRARC framework. Table 1 summarizes the identified hazards, their potential consequences, and the calculated risk levels ($R = L \times S$).

Table 1. Risk Analysis and Control Efforts

No	Activity	Hazard Type	Hazard Description	L	S	R	Risk Level	Risk Control Efforts
1	Receiving dirty linen	Biological	Exposure to microorganisms from contaminated linen	2	3	6	Medium	Use of PPE (masks & gloves), disinfection of receiving area
2	Handling wet linen	Ergonomic	Lifting heavy wet linen	3	3	9	Medium	Use of handling aids/trolleys, lifting technique training

No	Activity	Hazard Type	Hazard Description	L	S	R	Risk Level	Risk Control Efforts
3	Washing process	Chemical	Exposure to detergent or chlorine vapor	2	4	8	Medium	Adequate room ventilation, use of chemical-resistant masks & gloves
4	Extraction process	Mechanical	Hand caught in rotating machine	2	5	10	High	Installation of machine safety interlocks, SOP enforcement
5	Drying process	Physical	Contact with hot dryer surfaces or steam	2	3	6	Medium	Use of heat-resistant gloves, warning signage
6	Ironing process	Physical	Contact with hot iron roller surface	3	3	9	Medium	Installation of safety guards, operational training
7	Folding & packaging	Ergonomic	Awkward posture and repetitive movements	3	2	6	Medium	Adjusting work table height, periodic muscle stretching
8	Storing clean linen	Mechanical	Trolley collapse or foot injury	2	3	6	Medium	Trolley wheel maintenance, organized storage area
9	Distribution to wards	Mechanical/Physical	Slipping or muscle strain when pushing trolley	3	3	9	Medium	Use of anti-slip footwear, ergonomic pushing training
10	Machine cleaning	Electrical/Physical	Electric shock or slip while cleaning wet machine	2	5	10	High	Implementation of Lockout-Tagout

No	Activity	Hazard Type	Hazard Description	L	S	R	Risk Level	Risk Control Efforts
								(LOTO), ensuring dry surfaces

Note:

L (Likelihood): The probability of the event occurring.

S (Severity): The potential impact/consequence.

R (Risk): The risk score ($R = L \times S$).

The **Risk Control Efforts** column provides standard OHS (Occupational Health and Safety) recommendations; please ensure they align with the specific SOPs used in your research setting.

Risk Distribution

Out of the ten activities assessed, two activities (20%) were classified as high risk, namely: Extraction process ($R = 10$) and Machine cleaning ($R = 10$). Eight activities (80%) were categorized as medium risk, mainly due to repetitive motion, heavy lifting, heat exposure, or contact with biological contaminants. No activities were classified as low risk.

Hazard Categories

Across all activities, the most frequently observed hazard categories were: mechanical hazards (30%), ergonomic hazards (20%), physical hazards (20%), chemical hazards (10%), biological hazards (10%), and electrical hazards (10%). This pattern suggests that mechanical and ergonomic factors dominate the laundry work environment, consistent with findings from similar studies in hospital support units.

Summary of Risk Evaluation

The overall risk profile demonstrates that the laundry unit's work system is moderately hazardous, with certain operations requiring immediate engineering and administrative control. The two high-risk operations—extraction and machine cleaning—pose a direct threat of serious injury if left unmanaged. Meanwhile, medium-risk activities, such as lifting wet linen or ironing, may lead to chronic musculoskeletal disorders or minor thermal injuries if not supported by ergonomic design and consistent PPE usage.

Key Findings

- A total of 10 hazard points were identified, predominantly in mechanical and ergonomic categories.
- 80% of tasks were medium-risk, and 20% were high-risk.
- The most critical hazards included mechanical entrapment during extraction and electrical shock during machine cleaning.
- The findings highlight the need for routine risk monitoring, equipment maintenance, and operator training to reduce incident probability.
- Implementation of engineering controls and ergonomically designed tools is strongly recommended to minimize medium-level risks.

DISCUSSION

The present HIRARC assessment of the hospital laundry unit identified a predominance of medium-level risks across routine activities and two critical high-risk tasks (extraction and machine cleaning). This mixed risk profile is consistent with broader evidence showing that hospital laundry environments combine chronic ergonomic exposures (lifting, repetitive motion) with episodic but severe mechanical and electrical hazards. Ergonomic exposures are a well-documented source of work-related musculoskeletal disorders (WMSDs) among laundry and cleaning personnel, particularly where wet, heavy loads and repetitive postures occur. These findings align with recent ergonomic analyses and WMSD prevalence studies in healthcare support settings (El-Sayed et al., 2023).

Mechanical entrapment during extraction (e.g., hands near rotating drums) and electrical risks during machine cleaning are particularly concerning because they combine moderate likelihood with high severity a combination that typically elevates risk priority in HIRARC. International guidance and case studies emphasize that machinery guarding, lockout–tagout (LOTO) procedures, and clear SOPs for cleaning and maintenance are essential to prevent catastrophic injuries. Our identification of these high-risk operations therefore supports prioritizing engineering controls and administrative controls (maintenance schedules, LOTO, operator training)(HSA, 2023).

Biological and chemical hazards observed (contaminated linen, detergent/chlorine vapors) reflect ongoing infection prevention and occupational health concerns in laundering patient textiles. Infection prevention authorities and hospital laundry guidelines stress proper containment of contaminated linen, minimal agitation during handling, and adequate ventilation to reduce aerosolization and chemical exposure controls that also lower exposure potential for laundry staff. These control measures dovetail with PPE use, but multiple studies note that PPE alone is insufficient unless supported by engineering and administrative measures(CDC, 2024).

The predominance of medium-risk tasks (80% of activities) indicates a systemic, cumulative risk for chronic injuries and illnesses. Medium risks such as repetitive postures, manual handling of wet loads, and prolonged standing are strongly associated with increased prevalence of musculoskeletal complaints and reduced work capacity over time. Interventions shown to reduce WMSD burden include task redesign (mechanical hoists, trolleys, lighter loads), work–rest scheduling, and targeted ergonomic training strategies recommended by occupational safety agencies and supported by recent research in hospital settings (Labor, 2025).

Worker knowledge, attitudes, and practice (KAP) regarding PPE and safe work procedures influence the effectiveness of any control program. Several recent field studies of hospital laundry workers report gaps in PPE availability, inconsistent compliance, and limited hazard awareness as barriers to safer practice. Thus, an integrated approach combining reliable PPE supply, participatory training, and supervisory enforcement is required to translate policy into reduced exposure. Behavioural and organizational interventions (safety leadership, routine safety briefings) have been effective in improving compliance and reducing incidents in similar contexts (El-Sayed et al., 2023).

Environmental and infrastructural factors also shape risk. Inadequate ventilation, poor drainage, suboptimal workflow layout, and slippery floors increase slips, exposure to aerosols, and ergonomic strain. International infection control and occupational safety guidance for healthcare laundry emphasize facility design (separate clean/dirty flows, leak-resistant bags, ventilation) to mitigate these hazards. Implementing these infrastructural controls can be resource-intensive but often yields durable reductions in both acute and chronic risk(CDC, 2024).

From a practical HIRARC perspective, the hierarchy of controls suggests the following priority actions for this laundry unit: (1) immediate engineering fixes for the extraction machine (guards, emergency stops), (2) enforceable LOTO and cleaning SOPs supported by training, (3) ergonomic aids for manual handling (trolleys, adjustable work heights), (4) improved ventilation and chemical handling procedures, and (5) continuous PPE availability and behavior-change interventions. Recent implementation studies demonstrate that combining engineering and administrative controls yields greater risk reduction than PPE-centric programs alone (CDC, 2024).

Finally, monitoring and continuous improvement are critical. Regular hazard re-assessments, near-miss reporting, incident investigation, and worker health surveillance (periodic musculoskeletal and skin/respiratory checks) allow early detection of emerging problems and assessment of control effectiveness. The HIRARC process should therefore be iterative: implementation → monitoring → re-assessment. Published evidence from hospital settings supports the value of ongoing audits and participatory risk management to sustain improvements(Mersal et al., 2025).

Limitations. This discussion is based on a single-site assessment with a small respondent pool (n = 10) and thus may not be generalizable across different hospitals or regions. Nevertheless, the risk profile mirrors patterns reported in multicenter and regional studies, suggesting external relevance.

Future work should include larger samples, objective exposure measures (e.g., noise, heat, airborne particles), and post-intervention evaluations to quantify the impact of implemented controls (Iwg & Nlgam, 2024).

CONCLUSIONS

This study utilized the HIRARC framework to identify ten distinct operational activities in the hospital laundry unit, revealing that while 80% of tasks present medium-level risks, machine extraction and cleaning pose high-risk threats of mechanical entrapment and electrical shock. The cumulative exposure to ergonomic stressors, heat, and chemicals further heightens the likelihood of chronic health issues among personnel, underscoring the necessity for structured risk management to safeguard worker well-being.

To mitigate these hazards, it is essential to prioritize engineering controls, such as machine guarding and ergonomic redesigns, alongside administrative measures like implementing strict Lockout-Tagout (LOTO) procedures and regular safety training. Furthermore, hospital management should integrate periodic HIRARC reassessments and participatory safety planning into the facility's culture, while future research is encouraged to expand these evaluations to other support units to ensure comprehensive occupational safety across healthcare environments.

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Availability of data and materials

All data generated or analysed during this study are included in this published article.

Authors' contributions

AF conceptualized and designed the study, developed the research framework and hypotheses, conducted data collection and statistical analysis, interpreted the findings, and drafted as well as critically revised the manuscript. The author approved the final version of the manuscript and agrees to be accountable for all aspects of the work, ensuring its accuracy and integrity.

Conflict of Interest

There is no conflict of interest in this research.

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