

Original Article

Risk assessment of sharps medical waste management using the HIRARC approach in a primary healthcare clinic

Joko Sistriyono^{1*}, Arie Wahyudi¹, Dianita Ekawati¹, Heriziana¹

¹ Sekolah Tinggi Ilmu Kesehatan Bina Husada, Palembang, Indonesia

***Corresponding Author:**

Joko Sistriyono

Sekolah Tinggi Ilmu Kesehatan Bina
Husada, Palembang, Indonesia
Email:
jokosistriyono8@gmail.com

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Abstract

Background: Medical sharps waste is a hazardous component of healthcare waste that may cause sharps injuries, exposure to infectious agents, and environmental contamination when inadequately managed. Suboptimal practices during segregation, containment, internal transportation, and temporary storage may increase health and safety risks for healthcare workers, waste-handling personnel, patients, and the surrounding environment.

Objective: This study aimed to identify hazards, assess risk levels, and evaluate risk-control measures in medical sharps waste management using the Hazard Identification, Risk Assessment, and Risk Control (HIRARC) approach at Rezky Medika Clinic, Palembang, Indonesia.

Methods: A descriptive qualitative design complemented by HIRARC-based risk assessment was employed from February to April 2026. Participants were purposively selected and comprised five informants for in-depth interviews and eight participants in focus group discussions. Data were collected through in-depth interviews, field observations, document review, and focus group discussions. Qualitative data were analyzed through transcription, coding, categorization, theme identification, verification, and source triangulation.

Results: The HIRARC assessment identified 12 risks across source segregation, containment, internal transportation, and temporary storage. The highest-ranked risk was needlestick injury associated with an overfilled safety box during the containment stage, with a risk score of 12 and classified as high risk. Moderate risks were primarily associated with waste spills, cross-infection, occupational accidents, and contamination of clinical areas during containment and internal transportation. Although several control measures were already implemented, gaps remained in procedural compliance, infrastructure availability, personal protective equipment use, supervision, and continuous staff training.

Conclusion: Medical sharps waste management remains associated with occupational and environmental health risks that require more systematic control. The HIRARC approach provides a practical framework for identifying critical risk points and prioritizing preventive measures to strengthen safe medical waste management in healthcare facilities.

Background

Health-care activities generate both general and hazardous waste streams. The World Health Organization (WHO) estimates that approximately 85% of health-care waste is non-hazardous and 15% is hazardous, including infectious, chemical, radioactive, and sharps waste (World Health Organization, 2024). Sharps waste includes needles, syringes with attached needles, infusion sets, scalpels, blades, pipettes, and broken glass and is especially important because it combines mechanical injury risk with potential exposure to blood-borne pathogens (Chartier et al., 2014; World Health Organization, 2024). Global health-care waste generation varies substantially across settings and continents, while waste segregation, storage, transportation, and treatment remain inconsistent in many low- and middle-income settings (Fadaei, 2023; Mol et al., 2022; Ranjbari et

al., 2022). WHO and UNICEF have also highlighted persistent gaps in basic health-care waste services, particularly in resource-constrained and fragile settings (World Health Organization & United Nations Children's Fund, 2024).

Needlestick and other sharps injuries remain a major occupational hazard. A 2023 systematic review and meta-analysis estimated a pooled global needlestick-injury prevalence of 40.97% among nurses, with the highest regional subgroup estimate reported in Southeast Asia (Abdelmalik et al., 2023). Under-reporting is also common; a systematic review found that many needlestick injuries among health-care workers are never formally reported, limiting organizational learning and prevention (Behzadmehr et al., 2021). Other reviews have linked occupational injuries to inconsistent standard precautions, training gaps, workload, resource limitations, and previous sharps exposure (Debelu et al., 2023; Fathizadeh

et al., 2023). Indonesian literature similarly identifies needlestick injuries as a continuing occupational-health concern among health workers (Balgahoom et al., 2024). Historical global estimates of infections attributable to unsafe injections further demonstrate the consequences of poor injection and sharps safety (Pépin et al., 2014).

In Indonesia, medical waste management is regulated through Ministry of Health Regulation No. 18 of 2020 on area-based management of medical waste from health-care facilities (Ministry of Health of the Republic of Indonesia, 2020). Nevertheless, empirical studies continue to identify operational gaps in segregation, storage, infrastructure, staff compliance, monitoring, and transport. Studies in Indonesian community health centers and clinics have reported mixing of medical and non-medical waste, prolonged temporary storage, inadequate dedicated resources, and incomplete monitoring systems (Dipesi & Gumayesty, 2024; Priyatno, 2022; Ratnaningtyas et al., 2021). Hospital-based research has also identified the influence of policy, infrastructure, staff behavior, and treatment methods on waste-management performance (Hutajulu et al., 2022; Usnaini et al., 2025). A recent Indonesian review similarly emphasized persistent gaps in source segregation, waste tracking, human-resource capacity, and supervision (Nurlaili et al., 2025).

Most of this literature is primarily compliance-oriented or descriptive. Environmental risk studies using life-cycle assessment provide valuable information about downstream environmental impacts but do not directly prioritize stage-specific occupational risks during sharps handling (Irawati et al., 2024). International research likewise emphasizes that segregation, collection, worker behavior, training, and organizational systems remain central challenges in health-care waste management (Jangre et al., 2024; Tushar et al., 2023). Consequently, a complementary risk-based approach is useful to identify hazards, rate their operational priority, and link each priority to specific controls. HIRARC provides a structured sequence of hazard identification, risk assessment, and risk control and can support this purpose (Department of Occupational Safety and Health Malaysia, 2008; International Organization for Standardization, 2018).

This study therefore aimed to evaluate sharps medical waste management at a private clinic in Palembang, Indonesia; identify hazards across

segregation at source, containment, internal transport, and temporary storage; prioritize the identified hazards using a HIRARC risk matrix; and describe existing and needed risk-control measures. By adding explicit risk prioritization to a predominantly compliance-focused evidence base, the study is intended to support practical occupational-health, environmental-health, and facility-management decisions.

Methods

Study Design

This was a qualitative descriptive, single-site study supplemented by a structured HIRARC risk assessment. Qualitative data were the primary source for understanding waste-management practices and operational gaps, while numerical HIRARC scores were used to map and prioritize the identified risks. Because the study used in-depth interviews and a focus group discussion (FGD), the reporting of the qualitative component was guided by the Consolidated Criteria for Reporting Qualitative Research (COREQ) (Tong et al., 2007). The HIRARC process followed the principles of hazard identification, risk analysis, and control described in HIRARC guidance and broader risk-management standards (Department of Occupational Safety and Health Malaysia, 2008; International Organization for Standardization, 2018; Standards Australia & Standards New Zealand, 2004). Foundational risk-assessment concepts were also considered in interpreting the likelihood-severity matrix (Covello & Merkhofer, 1993).

Setting

The study was conducted at Rezky Medika Clinic, a private health-care facility in Palembang, Indonesia, from February to April 2026. The clinic provides 24-hour services, including an emergency department, pediatric clinic, obstetrics and gynecology clinic, dental clinic, and inpatient care. The facility employed 36 workers across medical, nursing/health, support, administrative, security, and cleaning functions. The study focused on sharps medical waste generated and handled within the clinic up to temporary storage; off-site final treatment was conducted by a licensed third party and was not included in the scored HIRARC scope.

Participants and Sampling

Purposive sampling was used to recruit personnel whose roles were directly related to the planning, supervision, or operational handling of sharps medical waste. Five participants took part in in-depth interviews: one key informant (the clinic's responsible physician) and four main informants representing quality assurance, human resources/personnel, finance, and cleaning/waste coordination. The finance coordinator was included because this role contributed to planning and implementation of medical-waste transport arrangements. The FGD included eight operational personnel: three cleaning staff, one temporary-storage (TPS) officer, two security personnel, and two medical-waste transport workers. The sample was role-based and purposive; no statistical sample-size calculation was applied.

Data Sources and Data Collection

Data were collected through in-depth interviews, field observation, document review, and one FGD. The interview guide was organized around the sharps-waste pathway—segregation at source, containment, internal transport, and temporary storage—and the 5M domains used in the original study (man, method, mechanism/equipment, material, and environment). Individual interviews lasted approximately 20–45 minutes. With participant consent, interviews were audio-recorded using a mobile phone, and the researcher also documented relevant field notes. Recordings were replayed to support transcription and data verification. When information was unclear, clarification or repeat interviews were undertaken. Selected information was returned to participants for member checking. Field observations and documentary data were used to triangulate interview and FGD findings.

Qualitative Data Analysis

Audio recordings were transcribed into written text and checked against the original recordings. The researcher then identified statements relevant to waste segregation, sharps-container use and capacity, personal protective equipment (PPE), internal transport, infrastructure, staff competence, exposure hazards, and risk controls. Coding was performed by one researcher using Microsoft Word and Microsoft Excel. Codes were grouped into categories aligned with the four management stages and the 5M domains. A

structured analytic matrix was used to compare informants and connect interview findings with observation and document-review evidence. Categories and final interpretive statements were retained when they were consistent with the available transcript evidence, field context, and study focus. This analytic approach was informed by established qualitative data-analysis principles (Miles et al., 2014).

HIRARC Risk Assessment

The identified hazards were assessed using the Hazard Identification, Risk Assessment, and Risk Control (HIRARC) approach. The risk score was calculated by multiplying likelihood by severity. Likelihood was rated on a five-point scale: 1 (very rare; less than once per year), 2 (rare; 1–2 times per year), 3 (occasional; 3–6 times per year), 4 (frequent; occurring monthly), and 5 (very frequent; occurring weekly or daily). Severity was also rated on a five-point scale: 1 (insignificant; no injury or loss), 2 (minor; minor injury or limited disruption), 3 (moderate; requiring medical treatment), 4 (major; serious injury or environmental contamination), and 5 (catastrophic; resulting in death, outbreak, or severe legal consequences). The resulting risk scores were classified into four categories: low risk (1–4), requiring routine control and monitoring; moderate risk (5–9), requiring additional control and active monitoring; high risk (10–16), requiring priority corrective action; and extreme risk (17–25), requiring immediate control or action. The risk-category cutoffs were retained from the source study's risk matrix. HIRARC was applied as an operational tool for prioritizing identified hazards rather than as an inferential statistical analysis.

Rigor and Trustworthiness

Credibility was supported through triangulation of in-depth interviews, the FGD, field observations, and document review; follow-up clarification where information was unclear; and selected member checking. Dependability was strengthened by audio recording, transcript checking, and use of a structured analytic matrix. Participant identifiers were replaced by codes. Because coding was conducted by a single researcher, no intercoder-agreement procedure was performed; this is acknowledged as a methodological limitation rather than being retrospectively inferred.

Ethical Considerations

Participants received study information before data collection, audio recording was conducted after consent, and participant identities were anonymized using codes in the analytic process.

Results

Rezky Medika Clinic employed 36 staff members. Most were women (77.78%) and younger than 55 years (86.11%). Professional physicians represented 30.55% of employees, followed by diploma-level personnel (22.22%). During 2025, the clinic recorded 624 kg of total waste, comprising domestic waste (38%), solid medical

waste including sharps (35%), and other medical waste (27%). These contextual data indicate a substantial medical-waste stream requiring consistent segregation, containment, transport, storage, and external treatment.

From February through April 2026, the clinic generated 249.73 kg of sharps medical waste, with a monthly average of 83.24 kg. The emergency department generated the largest share (34.69%), followed by the obstetrics and gynecology clinic (19.61%), pediatric clinic (18.15%), dental clinic (15.66%), and inpatient ward (11.89%). The distribution of waste generation is shown in Table 1.

Table 1. Sharps medical waste volume by service unit, February–April 2026

Service unit	Feb (kg)	Mar (kg)	Apr (kg)	Total (kg)	Monthly mean (kg)	%
Emergency department	26.70	28.53	31.40	86.63	28.88	34.69
Pediatric clinic	16.50	18.13	10.70	45.33	15.11	18.15
Dental clinic	9.20	10.10	19.80	39.10	13.03	15.66
Obstetrics and gynecology clinic	13.80	15.87	19.30	48.97	16.32	19.61
Inpatient ward	7.90	10.20	11.60	29.70	9.90	11.89
Total	74.10	82.83	92.80	249.73	83.24	100.00

Triangulated field observations, interview material, the FGD, and documentary information indicated recurring operational concerns along the sharps-waste pathway. At source, safety boxes were not consistently available in every service area and mixing of sharp and non-sharp waste had occurred. During containment, overfilling of sharps boxes created a direct needlestick hazard. Internal transport concerns included incomplete

PPE use, direct contact with waste, potential spills, and use of common circulation routes. Temporary-storage concerns included waste accumulation, leakage, odor, environmental contamination, and potential microbial growth. Delays in third-party collection were also identified as an operational concern. These findings informed the HIRARC hazard-identification step.

Table 2. Hazard identification in sharps medical waste management

Management stage	Hazard source	Identified risk
Segregation at source	Needles; ampoules; vials	Needlestick injury; abrasion/cut; laceration
Containment	Overfilled sharps container; damaged/leaking container	Needlestick injury; waste spillage; environmental contamination
Internal transport	Waste spillage; direct contact; use of common routes	Cross-infection; occupational accident; contamination of clinic areas
Temporary storage	Waste accumulation; leakage; pathogen exposure	Odor; environmental contamination; microbial growth
Final treatment (context only)	Gas emissions; heat; mechanical equipment	Air pollution; respiratory effects; occupational accident

Table 3 showed twelve risks were scored across the four in-scope management stages. The highest-priority risk was a needlestick injury caused by an overfilled sharps container during containment (risk score 12; high). Four risks were moderate: waste spillage during

containment (8), cross-infection during internal transport (6), occupational accident during internal transport (8), and contamination of clinic areas during internal transport (6). The remaining seven risks were low. No extreme risks were reported.

Table 3. HIRARC risk assessment for sharps medical waste management

Management stage	Risk	Likelihood	Risk score	Risk level
Segregation at source	Needlestick injury	2	4	Low
Segregation at source	Abrasion/cut from ampoule	2	2	Low
Segregation at source	Laceration from vial	2	2	Low
Containment	Needlestick injury from overfilled container	3	12	High
Containment	Waste spillage	2	8	Moderate
Containment	Environmental contamination	2	4	Low
Internal transport	Cross-infection	3	6	Moderate
Internal transport	Occupational accident	2	8	Moderate
Internal transport	Contamination of clinic areas	2	6	Moderate
Temporary storage	Odor	2	4	Low
Temporary storage	Environmental contamination	2	4	Low
Temporary storage	Microbial growth	2	4	Low

Table 4 showed existing controls included puncture-resistant safety boxes, SOPs for segregation and transport, PPE, closed/labelled containers, a dedicated trolley for internal transport, a temporary storage area separated from clinical care, and coordination with a

licensed third-party waste handler. However, the persistence of moderate and high risk scores indicated that implementation and monitoring of these controls were not sufficient to eliminate operational vulnerabilities.

Table 4. Existing risk controls aligned with the scored HIRARC risks

Management stage	Risk	Risk level	Existing control
Segregation at source	Needlestick injury	Low	Safety boxes available in service areas; segregation SOP
Segregation at source	Abrasion/cut from ampoule	Low	Puncture-resistant sharps container
Segregation at source	Laceration from vial	Low	Separation of sharps from non-sharps waste
Containment	Needlestick injury from overfilled container	High	Use of standard sharps container
Containment	Waste spillage	Moderate	Closed and labelled waste container
Containment	Environmental contamination	Low	Waste containers separated by waste type
Internal transport	Cross-infection	Moderate	Closed trolley and PPE
Internal transport	Occupational accident	Moderate	PPE and transport SOP
Internal transport	Contamination of clinic areas	Moderate	Closed trolley during transport

Management stage	Risk	Risk level	Existing control
Temporary storage	Odor	Low	Closed TPS separated from service areas
Temporary storage	Environmental contamination	Low	Watertight TPS with hazardous-waste signage
Temporary storage	Microbial growth	Low	Closed TPS with routine cleaning

Discussion

This study identified a clear hierarchy of operational risks in sharps medical waste management. Among 12 scored risks, the only high-risk item was needlestick injury associated with an overfilled sharps container, while moderate risks clustered around waste spillage and internal transport. This pattern is important because it moves the analysis beyond whether a procedure or facility is present and toward whether existing controls are sufficiently effective at the points where workers are most exposed. HIRARC therefore provided an operational prioritization layer that complements regulatory and procedural compliance assessment.

The high priority assigned to overfilled sharps containers is consistent with international evidence that sharps injuries remain common and are strongly influenced by work practices, standard-precaution adherence, resources, and safety systems (Abdelmalik et al., 2023; Debelu et al., 2023). WHO guidance recommends puncture-resistant sharps containers and timely collection before containers become overfilled, because manual manipulation around exposed sharps increases the probability of injury (Chartier et al., 2014; World Health Organization, 2024). The finding is also compatible with Indonesian evidence showing that sharps injuries and waste-handling problems continue to occur where procedures, infrastructure, or supervision are inconsistent (Balgahoom et al., 2024; Usnaini et al., 2025).

Moderate risks during internal transport—cross-infection, occupational accidents, and contamination of clinic areas—show that risk does not end at the point of segregation. Closed trolleys, PPE, route control, and spill prevention are important engineering and administrative controls. Research from developing health-care systems has repeatedly identified segregation, collection, transport, infrastructure, and staff behavior as interacting components rather than isolated tasks (Fadaei, 2023; Jangre et al., 2024;

Tadesse & Dolamo, 2022). The clinic's use of a closed trolley and PPE is therefore appropriate, but the observed use of common routes and inconsistent PPE indicates a gap between available controls and reliable implementation.

The Indonesian evidence base supports this interpretation. Community health-center and clinic studies have documented mixed waste streams, prolonged storage, resource constraints, and incomplete oversight (Dipesi & Gumayesty, 2024; Priyatno, 2022; Ratnaningtyas et al., 2021). Hospital research has similarly shown that policy, infrastructure, staff behavior, and treatment systems influence medical-waste performance (Hutajulu et al., 2022). The recent national literature review by Nurlaili et al. (2025) further emphasizes the importance of data-based risk control, staff capacity, and transparent monitoring. The present study adds to those findings by explicitly ranking the risk consequences of operational gaps rather than reporting compliance alone.

Risk-based prioritization is also complementary to environmental approaches such as life-cycle assessment. Irawati et al. (2024) assessed environmental impacts across the broader medical-waste life cycle, whereas HIRARC is more directly suited to task-level hazard prioritization for workers and immediate facility environments. Both perspectives are valuable: environmental assessment identifies downstream burden, while HIRARC directs local corrective action toward specific tasks. The broader literature on sustainable health-care waste management similarly recommends combining safe segregation, operational redesign, staff training, monitoring, and environmentally responsible treatment (Lattanzio et al., 2022; Ranjbari et al., 2022; Slutzman et al., 2023; Tushar et al., 2023).

For practice, the most immediate intervention is to establish an explicit sharps-container replacement trigger and ensure that containers are replaced before overfilling. WHO guidance commonly uses a three-quarter-full threshold for

collection of sharps containers (Chartier et al., 2014). Second, internal transport should use a defined route and schedule that minimize contact with patients and general circulation areas. Third, PPE compliance should be reinforced through supervision, visual reminders, and routine audit rather than relying solely on written SOPs. Evidence from intervention studies indicates that education alone is often insufficient and that multimodal approaches combining system change, training, reminders, monitoring, and feedback produce stronger improvements in biomedical waste practices (Ara et al., 2022; Ashtari et al., 2020). Finally, risk scores should be reviewed periodically and after incidents, workflow changes, or changes in waste volume, consistent with iterative risk-management principles (Department of Occupational Safety and Health Malaysia, 2008; International Organization for Standardization, 2018).

The study has several limitations. It was conducted at a single private clinic, so transferability to hospitals, public primary-care facilities, or other regions should be considered cautiously. Participants were selected purposively based on their roles, and the qualitative analysis was conducted by one researcher. HIRARC scoring is semi-quantitative and context dependent; it prioritizes hazards but does not estimate incidence or causal effects. The study did not report an objective incidence rate for needlestick injuries, and the source manuscript did not include verbatim participant quotations, which limits the transparency of the qualitative evidence trail. These limitations do not negate the operational value of the risk prioritization, but they should be considered when interpreting and applying the findings.

Conclusion and Recommendation

Sharps medical waste management at Rezky Medika Clinic involved identifiable occupational and environmental risks across segregation, containment, internal transport, and temporary storage. HIRARC identified overfilled sharps containers as the highest-priority risk and internal transport as a second critical control point. The most practical priorities are timely replacement of sharps containers, consistent PPE use, safer transport routes, stronger supervision of SOP implementation, routine waste and incident monitoring, and periodic reassessment of risk controls. These findings support the use of

HIRARC as a practical complement to regulatory compliance assessment for translating waste-management gaps into prioritized corrective actions.

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Declaration of conflict of interest

The authors declare no competing interests.

Declaration on the Use of AI

Artificial Intelligence (AI) tools, namely ChatGPT (OpenAI), were used solely to assist in language editing, grammar checking, and improving the readability of the manuscript. All scientific content, data analysis, interpretation of results, and conclusions were developed and verified by the authors. The authors take full responsibility for the content of this manuscript.

Data Availability Statement

Data sharing is not applicable to this article.

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