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Assessment of Infectious Solid Medical Waste Management Practices at Hospital X Surabaya

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ABSTRACT Hospitals are essential for providing medical care, yet they also contribute significantly to environmental degradation through the generation of infectious solid medical waste. Preliminary observations at Hospital X Surabaya revealed several deficiencies in waste management practices, particularly in containment, transportation, storage, human resources, and infrastructure. This study aimed to assess the compliance of infectious solid medical waste management at Hospital X Surabaya with the Minister of Health Regulation Number 2 of 2023. A descriptive cross-sectional design was employed, involving direct observations and interviews with waste management personnel. The volume of infectious waste generated was recorded over seven consecutive days and evaluated against national regulatory standards. Results showed that the hospital produced an average of 5.34 kg of infectious waste per day. While waste sorting and external processing met the stipulated criteria, other key aspects namely containment, transportation, temporary storage, human resources, and facilities did not comply with regulatory standards. Containers were often overfilled and improperly sealed; waste was transported manually without trolleys or complete personal protective equipment (PPE); and storage conditions failed to meet temperature requirements due to equipment malfunction. Moreover, many waste handlers had not received adequate training, and critical infrastructure such as labeled trolleys and PPE remained insufficient. These findings highlight the need for immediate improvements across multiple dimensions of medical waste management to mitigate environmental and health risks. Strengthening infrastructure, ensuring proper training, and enforcing compliance are vital to achieving safe and sustainable medical waste handling practices.

INDEX TERMS Infectious waste, medical waste management, hospital sanitation, environmental health, healthcare regulation

I. INTRODUCTION

Hospitals serve as critical institutions for the diagnosis, treatment, and rehabilitation of patients. However, their operations produce a significant amount of infectious solid medical waste, which, if not managed properly, poses severe threats to public health and the environment [1]–[3]. Infectious medical waste, particularly that generated from patient care activities such as surgery, laboratory diagnostics, and inpatient care, contains pathogens capable of causing nosocomial infections, environmental contamination, and occupational hazards for healthcare workers [4], [5]. The World Health Organization (WHO) estimates that developing countries produce between 1 to 3 kg of medical waste per bed per day, with waste potentially increasing in tandem with hospital activity and patient volume [6].

In Indonesia, the management of infectious solid medical waste is governed by Minister of Health Regulation No. 2 of 2023, which mandates health facilities to implement waste management systems that include waste segregation, containment, transportation, temporary storage, and final treatment [7]. However, compliance with these regulations remains inconsistent. According to the Ministry of Health, only 38.9% of healthcare facilities nationwide adhere to these standards, despite an increase from the previous year [8]. Recent studies have reported persistent issues in the implementation of these regulatory components. Ronald et al. [9] identified major barriers to waste management in regional hospitals, including inadequate infrastructure, lack of trained personnel, and insufficient budget. Hanako and Trihadiningrum [10] observed poor waste storage conditions and unclear standard operating procedures (SOPs) at Hospital X Surabaya, leading to secondary contamination. Fitrianingsih [11] highlighted that hospital often lack basic tools such as color-coded trolleys and temperature-regulated storage rooms, contributing to improper handling and increased risk of infection.

Despite ongoing efforts, existing practices often fall short in applying best practices in the containment, transport, and temporary storage of infectious waste. While some facilities have adopted color-coded segregation systems and collaborate with licensed third-party processors [12], [13], these solutions are not uniformly implemented. The lack of trained personnel, inadequate personal protective equipment (PPE), and failure to maintain temperature control during storage remain pressing issues in healthcare waste management in Indonesia [14]–[16].

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Vol. 4 No.6, pp. 411-415, January 2025

This study aims to assess the compliance of infectious solid medical waste management practices at Hospital X Surabaya with national health and environmental regulations. The research provides a comprehensive evaluation of each management stage sorting, containment, transport, storage, and external processing along with supporting factors such as human resources and infrastructure.

This study offers three major contributions: (1) it provides empirical data on the volume and management quality of infectious waste in a mid-sized Indonesian hospital; (2) it identifies critical gaps in current hospital waste handling that deviate from Ministry of Health regulations; and (3) it proposes actionable recommendations to enhance waste safety practices, including training, infrastructure improvement, and policy enforcement.

II. METHODS

This research employed a descriptive, cross-sectional study design to assess the management of infectious solid medical waste at Hospital X Surabaya. The cross-sectional method was selected because it allows researchers to capture conditions at a specific point in time without manipulation of variables, thus providing a snapshot of current practices and compliance with established standards [31], [32].

A. STUDY LOCATION AND SETTING

The study was conducted at Hospital X, a mid-sized hospital located in Surabaya, East Java, Indonesia. The hospital has a capacity of 50 beds and an average daily bed occupancy rate of approximately 10.13%. It serves both inpatient and outpatient services and is equipped with emergency, surgical, laboratory, and maternity wards. The waste management system is coordinated by the sanitation unit, with staff assigned to oversee waste handling from the point of generation to temporary storage.

B. STUDY POPULATION AND SAMPLING

The target population comprised hospital personnel involved in infectious medical waste management, including sanitation coordinators and ward staff responsible for handling and transporting waste. A total sampling technique was used due to the manageable size of the population (N = 31). Total sampling is appropriate for small populations where all members can feasibly be included in data collection, ensuring comprehensive insights [33].

C. RESEARCH INSTRUMENTS AND MATERIALS

All instruments were validated through expert consultation and pre-tested to ensure clarity and reliability.The primary instruments used in this study included:

1. **Observation checklists**, structured according to Minister of Health Regulation No. 2 of 2023, which defines criteria for each stage of medical waste management, including sorting, containment, transport, storage, external processing, and supporting infrastructure.
2. **Interview guidelines**, developed to assess qualitative aspects such as staff training, adherence to protocols, and perceived challenges in waste handling.
3. **Digital weighing scale**, used to record the quantity of infectious solid medical waste generated per day over a 7-day period, measured in kilograms.

D. DATA COLLECTION PROCEDURES

Data were collected from January to February 2024 through:

1. **Direct observation** of waste management practices in relevant hospital departments using the checklist.
2. **Semi-structured interviews** with selected waste handlers and the sanitation coordinator to gain insights into procedural challenges and staff competence.
3. **Quantitative measurement** of the volume of infectious solid waste generated daily for seven consecutive days across different hospital units (emergency room, inpatient ward, laboratory, maternity ward, operating theatre, and outpatient clinic).

Each observation session was conducted in the morning between 05:30 and 06:30 to coincide with the hospital's waste collection schedule. Measurements were taken by trained researchers using a calibrated digital scale placed at the collection points.

E. VARIABLES AND ASSESSMENT CRITERIA

The main variables assessed were:

1. **Waste management process**: sorting, containerization, transportation, temporary storage, external processing.
2. **Supporting factors**: human resources (staff training, number of personnel) and facilities/infrastructure (availability of PPE, trolleys, labeled bins, storage equipment).

Each variable was scored as "compliant" or "non-compliant" based on whether all sub-criteria listed in Ministerial Regulation No. 2 of 2023 were fulfilled. A single point of failure within a variable was sufficient to classify it as non-compliant.

F. DATA ANALYSIS

The data were analyzed descriptively. Quantitative data from waste volume measurements were tabulated and averaged to determine daily waste generation. Observational and interview data were interpreted by comparing actual practices against regulatory standards. For example, if waste containers were overfilled beyond 75% capacity or lacked proper sealing, they were recorded as non-compliant in the containerization category. Similarly, if trolleys or complete PPE were not used during transportation, the transportation stage was deemed non-compliant. Results were presented in tabular format and discussed in comparison with national regulations and relevant literature on medical waste management.

G. ETHICAL CONSIDERATIONS

Ethical approval was obtained from the Research Ethics Committee of the Health Polytechnic of the Ministry of Health Surabaya. All participants provided verbal informed consent. Confidentiality was maintained by anonymizing respondent data and limiting access to interview transcripts to the research team only.

III. RESULT

A. VOLUME OF INFECTIOUS SOLID MEDICAL WASTE GENERATION AT HOSPITAL X SURABAYA

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Vol. 4 No.6, pp. 411-415, January 2025

The health service facilities at Hospital X Surabaya produce infectious solid medical waste every day. The waste is measured for 7 days based on the source of waste generation. Measurements are carried out to determine the fluctuation in the amount of waste produced. The following are the results of infectious medical waste measurements that have been carried out for 7 days based on the source:

TABLE 1
Results of Measurement of Infectious Solid Medical Waste Generation from the Source Room at Hospital X Surabaya in 2024

Room	Waste Generation Per Day (kg)							Total
	1	2	3	4	5	6	7	
IGD	2,7	2,3	2,5	0	0	0	0	7,5
Inpatient	4,8	3,3	3,5	3,0	2,8	2,6	0	20
Laboratory	2,7	0	2,4	0	0	0	0	5,1
Verlos Kamer	0	0	0	0	0	0	0	0
Surgery	0	0	0	0	0	0	0	0
Outpatient	0	2,5	0	2,3	0	0	0	4,8
Total waste per day (kg)	10,2	8,1	8,4	5,3	2,8	2,6	0	37,4
Average waste per day (kg)								5,34

Based on TABLE 1, the results of the measurement of infectious solid medical waste in six chambers for 7 days indicated that the amount generated was 37.4 kg with an average of 5.34 kg/day. It is known that inpatient rooms produce the most waste with a total of 20 kg per week. Waste was found at least in the verlos kamer and surgery room with an average of 0 kg per week because there were no medical actions that produced infectious solid waste during the measurement period.

B. MANAGEMENT OF INFECTIOUS SOLID MEDICAL WASTE

TABLE 2
Management of Infectious Solid Medical Waste at Hospital X Surabaya in 2024

Variable	Criterion	
	Qualify	Not Eligible
Management Process		
Waste sorting	√	
Waste containers		√
Waste transportation		√
Temporary storage		√
External processing	√	
Supporting Factors		
Human resources		√
Facilities and infrastructure		√

Based on TABLE 2, the criteria for managing infectious solid medical waste at Hospital X Surabaya have mostly not met the requirements. Based on the TABLE 2 there are only two variables that are eligible, namely the sorting stage and the external processing stage. A variable is considered eligible if all points in the criteria are met. On the other hand, if there is only one point that is not met, then the variable is categorized as ineligible.

IV. DISCUSSION

A. INTERPRETATION OF RESULTS

The assessment conducted at Hospital X Surabaya revealed a daily average of 5.34 kg of infectious solid medical waste over a seven-day period. The inpatient ward was the largest contributor, consistent with its function as a high-care unit. This figure aligns with WHO estimates, which suggest waste generation in developing countries typically ranges between 1–3 kg per bed per day, though Hospital X slightly exceeded this threshold due to concentrated patient activity in fewer operational units [38]. The absence of waste from the surgery and maternity rooms during the observation period was attributable to the lack of medical procedures conducted at that time. In terms of compliance with Ministry of Health Regulation No. 2 of 2023, only the waste sorting and external processing stages met the criteria. The stages of containerization, transportation, and temporary storage were found to be non-compliant. Waste was often stored beyond ¾ capacity, containers were improperly sealed, and manual transportation methods without PPE increased occupational risk. These findings underscore the systemic deficiencies in operational implementation and highlight potential exposure to infectious agents, as emphasized by WHO and national health authorities [39]. Human resources and supporting infrastructure also fell short of regulatory standards. While the waste coordinator was certified, most room-based waste handlers had not received specific training on hazardous waste procedures. Essential tools such as trolleys and complete personal protective equipment (PPE) were unavailable, increasing the potential for contamination and environmental leakage [40].

B. COMPARISON WITH SIMILAR STUDIES

The findings of this study are consistent with multiple assessments of medical waste management across Indonesia and other low-to-middle-income countries. A study by Hanako and Trihadiningrum [41] similarly found that Hospital X Surabaya lacked clear standard operating procedures (SOPs), especially for emergency waste situations, and experienced rodent intrusion due to poor waste storage practices. This reflects broader systemic weaknesses in institutional waste governance.In a study by Masgode et al. [42], facilities in Kolaka reported minimal waste from maternity wards, as was the case at Hospital X, due to low patient visits. Meanwhile, Suhermi et al. [43] emphasized that inadequate training among healthcare staff significantly undermined waste handling efficacy, echoing this study's findings regarding the lack of B3 waste management competency among frontline staff.

Furthermore, Fitrianingsih [44] reported that non-standardized transportation and overfilled containers were prevalent in multiple hospitals, leading to spillages and increased risks of pathogen exposure. The absence of dedicated trolleys and incomplete PPE were also found to compromise worker safety and operational efficiency issues that were also prominent in Hospital X Surabaya.While Hospital X has successfully partnered with licensed third-party providers for waste processing, an approach also documented by Pavitasari and Najicha [45], internal logistics prior to disposal remain insufficient. This internal–external gap in compliance has been reported by Rosa [46] as a recurring challenge in hospital waste systems throughout Indonesia. Globally, facilities that failed to maintain cold-chain waste storage reported microbial proliferation and environmental contamination [47], validating the risks found at Hospital X due to the damaged freezer and improper waste placement. Büchner et al. [48] further confirmed that poorly sealed containers significantly contribute to airborne pathogen

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release, making the failure to tie waste bags securely a considerable hazard.

C. LIMITATIONS AND IMPLICATIONS

Despite yielding comprehensive insights, this study is limited by its cross-sectional design, which captures conditions at a single point in time. Waste generation and management practices may vary across months depending on patient volume, staffing levels, and operational budget cycles. Future longitudinal research is recommended to assess seasonal trends in waste generation and compliance levels. Additionally, data were collected exclusively through direct observation and interviews. The absence of quantitative microbiological or environmental sampling (e.g., surface contamination, airborne particles) limits the ability to measure biological risk exposure levels in quantitative terms. Including such components in future research would enhance the understanding of actual infection transmission risks.

Nevertheless, the findings have significant implications for hospital management and policymakers. Firstly, there is an urgent need for regular and targeted training programs to build staff competency in infectious waste handling, as mandated by national guidelines. Hospitals should institutionalize a schedule for mandatory B3 waste training sessions, especially for room-based waste handlers who manage waste from the point of generation to storage. Secondly, resource allocation for facilities and equipment should be prioritized. Trolleys, PPE, and freezer units are not merely supporting tools they are integral to breaking the chain of infection transmission. The procurement process for such infrastructure should be accelerated and institutionalized through internal audits and regulatory inspections. Thirdly, hospital waste management should be framed not just as an operational task but as a strategic component of infection control and environmental health. The link between nosocomial infections and inadequate waste handling has been widely documented [49]. Therefore, improving waste protocols will likely yield broader benefits in patient and staff safety, aligning with the objectives of national public health standards. Lastly, inter-sectoral collaboration with third-party processors must include robust monitoring mechanisms. Although Hospital X has an MoU with licensed carriers and processors, hospital authorities must independently verify that waste reaches the designated treatment site using electronic manifest systems and geo-tracking tools, as promoted by the Ministry of Environment [50].

V. CONCLUSION

This study aimed to evaluate the compliance of infectious solid medical waste management practices at Hospital X Surabaya against the standards stipulated in the Indonesian Ministry of Health Regulation Number 2 of 2023. The findings revealed that the hospital generated an average of 5.34 kg of infectious solid waste per day over a 7-day observation period, with the inpatient ward being the largest contributor at 20 kg per week. While the hospital demonstrated compliance in waste sorting and external processing through licensed third-party partnerships, several critical areas were found to be non-compliant. Specifically, waste containers were often filled beyond ¾ of their capacity and improperly sealed; transportation was carried out manually without the use of labeled trolleys or complete PPE; and temporary storage was conducted at room temperature due to a malfunctioning freezer, exceeding the recommended time limits. Furthermore, human resources were inadequately trained, and essential infrastructure such as transport trolleys and PPE was lacking. These deficiencies pose significant risks to occupational safety and environmental health. To improve future compliance, it is essential for the hospital to implement structured training for all waste management personnel, allocate funding for equipment procurement, and establish continuous monitoring and evaluation mechanisms. Future research may expand by employing a longitudinal design to assess seasonal variations in waste volume and include microbiological analysis to quantify contamination risks associated with improper waste handling. Strengthening these aspects will contribute not only to regulatory compliance but also to enhancing hospital sanitation standards and patient safety outcomes.

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DATA AVAILABILITY

No datasets were generated or analyzed during the current study.

AUTHOR CONTRIBUTION

Vio Firdatus Vanesa conceptualized the study, conducted field observations, and drafted the manuscript. Ferry Kriswandana and Putri Arida Ipmawati contributed to data analysis and interpretation. Suprijandani assisted in literature review and regulatory alignment. Iva Rustanti Eri Wardoyo supervised the research process and provided critical revisions to the manuscript. All authors read and approved the final version of the paper.

DECLARATIONS

ETHICAL APPROVAL

This study was approved by the Ethics Committee of the Health Polytechnic of the Ministry of Health Surabaya. Verbal informed consent was obtained from all participants.

CONSENT FOR PUBLICATION PARTICIPANTS.

Consent for publication was given by all participants.

COMPETING INTERESTS

The authors declare no competing interests.

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