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# Evaluation of Solid Medical Waste Management in Bogor Regional Public Hospitals

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## Abstract

Healthcare facilities generate medical waste. If not properly managed, medical waste may damage the environment and spread diseases. Many hospitals in Indonesia do not adhere to medical waste management regulations. This study aimed to evaluate the management of solid medical waste at four public hospitals in Bogor District, Indonesia. A case study design was used to obtain a comprehensive description of the solid medical waste management activities in the hospitals. Data were collected through direct observations, interviews, and document reviews. This study revealed that the medical waste generated in all hospitals was infectious, pathological, pharmaceutical, chemical, and cytotoxic, totaling approximately 4,000-12,000 kg. Hospitals A, B, C, and D fulfilled the Regulation of the Indonesian Ministry of Environment and Forestry No. P56 of 2015 criteria, achieving compliance rates of 77%, 83.78%, 83.3%, and 86.48%, respectively. However, several activities of the hospitals did not meet the standards for waste reduction, segregation, on-site transport, temporary storage, and human resource quality. It is important that hospitals establish comprehensive and compliant medical waste management systems.

**Keywords:** regional public hospital, solid medical waste, waste management

## Introduction

Wastes are materials generated through human activities that cannot be recycled, discarded, or utilized.<sup>1</sup> Hospitals, as facilities where people seek healthcare services, typically generate both medical and non-medical waste. Medical waste is hazardous and toxic; therefore, it may adversely affect human health, cause accidents, and pollute the environment if incorrectly handled.<sup>2</sup> The World Health Organization (WHO) estimates that up to 15% of the waste generated by health facilities is medical waste.<sup>4</sup> Hospitals produce millions of tons of medical waste and utilize an estimated 16 billion needles annually.<sup>3,4</sup> However, the implementation of waste management is still poor, resulting in an enormous accumulation of medical waste that is not properly handled. Data from the WHO in 2015 stated that only half (58%) of health facility samples in 24 countries performed proper medical waste management.<sup>4</sup> Also, the WHO estimated that 23 million infectious diseases occur worldwide due to inadequate medical waste management.<sup>5</sup>

The handling of medical waste management in developing countries is quite worrisome. This is because he-

alth facilities have insufficient regulations, inadequate facilities, and challenges in monitoring waste management practices, such as segregation and disposal, within health facilities.<sup>6</sup> In addition, the reuse of needle waste from healthcare facilities in developing countries contributed to 33,800 new HIV cases, 1.7 million hepatitis B cases, and 315,000 hepatitis C cases.<sup>7</sup> As a developing country, Indonesia still has difficulties managing medical waste. In 2019, only 43% of hospitals complied with the regulations guiding the proper management of medical waste.<sup>8</sup> In the same year, the volume of medical waste produced by 2,820 hospitals and 9,884 primary health cares in Indonesia reached 290 tons/day.<sup>9</sup>

In contrast, the medical waste treatment capacity from hospital incinerators and licensed waste management services was only 220 tons/day, leaving 70 tons of waste neglected daily.<sup>9</sup> According to the Indonesian Ministry of Health data in 2022, approximately 84% of 402 hospitals did not provide medical waste management services for segregation and waste treatment.<sup>10</sup> The situation is exacerbated by the fact that there are only a few hospitals with licensed medical waste treatment faci-

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lities. Moreover, among 2,880 hospitals in Indonesia, only 120 have incinerators, and only 5 have autoclaves.<sup>10</sup> Furthermore, there are only 165 licensed waste transporters and 20 licensed waste treatment service providers with uneven distribution.<sup>2,10</sup>

West Java, one of Indonesia’s provinces, is the second-highest region with the most significant increase in medical waste generated during 2020-2021, up to 700 tons.<sup>11</sup> Furthermore, statistics from the Indonesian Ministry of Health data in 2022 show that 70.6% of hospitals in West Java Province do not provide medical waste management services, meaning that most hospitals in West Java Province do not perform waste segregation and treatment.<sup>12</sup> In Bogor, one of the widest districts in West Java Province, all the regional public hospitals do not perform waste management services based on the Indonesian Ministry of Health data in 2022.<sup>12</sup> Therefore, this study aimed to evaluate solid medical waste management at the public hospitals in Bogor District, West Java Province, Indonesia.

**Method**

This case study was conducted at four public hospitals (A, B, C, and D) in Bogor District, West Java, Indonesia. The selection of these hospitals was based on their classification as type-B facilities, characterized by complex facilities that produce substantial medical waste. These hospitals serve as local or regional referral hospitals. As per the data from the Indonesia Ministry of Health in 2022, they do not perform medical waste management according to the national waste segregation and treatment standard.<sup>12</sup>

This study was conducted from January to June 2023. Primary data were obtained through observations using checklist sheet requirements following the Regulation of the Indonesian Ministry of Environment and Forestry No. P56 of 2015. Additionally, interviews were conducted with the environmental health manager of each hospital to obtain information on medical waste characteristics and existing conditions for medical waste management. These include reduction activities, segregation, transportation, temporary storage, treatment, human resource quality, finance, and facilities and infrastructure. Secondary data were obtained through document review for policies, Standard Operational Procedures (SOP), permits, and reports related to medical waste management.

Data processing was carried out by summarizing and grouping data based on variables and then grading them according to the scope of the study. The data were analyzed by examining the characteristics of medical waste in each hospital, the availability of policies and SOP, facilities and infrastructure, finance and human resource quality, and the implementation of medical waste management between hospitals. Additionally, the percentage of

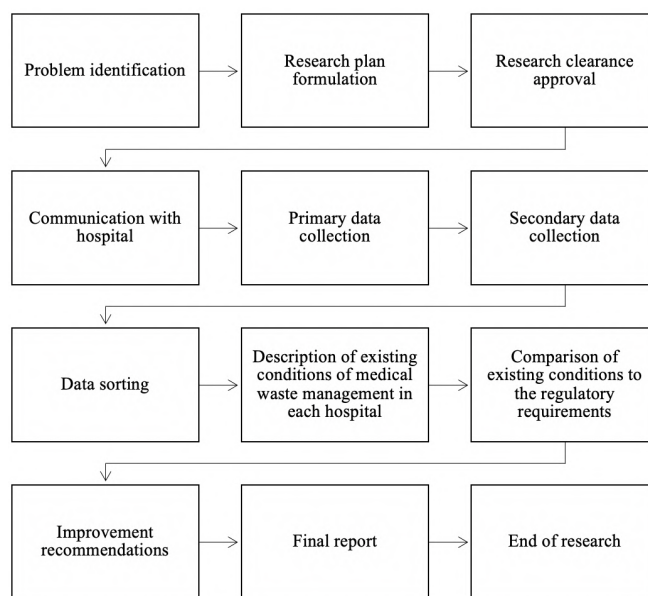


Figure 1. Study Framework

compliance with medical waste management was determined from a checklist. The data are displayed in narrative and tabular forms.

**Results**

*Characteristics of Solid Medical Waste*

Medical waste generated by four public hospitals in Bogor District included infectious materials, pathological waste, sharps, pharmaceuticals, and chemicals. Hospital B also produced cytotoxic waste from its chemotherapeutic activities. These wastes were generated from various facilities, including polyclinics, laboratories, pharmacies, radiology, hemodialysis, chemotherapy units, emergency rooms, intensive care units, inpatient and outpatient installations, forensic medical installations, neonatal-maternal installations, and surgical rooms. The data related to medical waste generation from January to April 2023 are compiled in Table 1.

*Reduction Activities*

In performing reduction activities, only Hospital A reused hemodialysis and laundry jerrycan waste as safety boxes; however, cleaning and disinfection were not conducted before their reuse. Furthermore, through collaboration with other parties, Hospital D recycled hemodialysis jerrycan, laundry jerrycan, and infusion plates not contaminated with patients’ fluid or blood samples into non-food-grade products. Additionally, Hospital D provided cleaning, immersion with disinfectants, and chopping before the waste was delivered to an external party

Table 1. Medical Waste Generation in Four Public Hospitals in Bogor District

Month	Hospital A		Hospital B		Hospital C		Hospital D	
	Total (Kg)	Average (Kg/day)	Total (Kg)	Average (Kg/day)	Total (Kg)	Average (Kg/day)	Total (Kg)	Average (Kg/day)
January	4,665.23	150.49	8,947.01	288.61	4,333.24	139.78	1,2895.38	415.98
February	4,010.03	143.22	7,668.87	273.89	4,249.01	151.75	11,509.26	411.04
March	5,265.43	169.85	9,335.69	333.42	4,998.46	161.24	12,640.86	407.76
April	4,363.79	145.46	7,961.15	284.33	4,102.94	136.76	11,364.9	378.83

Table 2. Fulfillment Recapitulation of Medical Waste Management Implementation

Medical Waste Management Stream	Hospital A (%)	Hospital B (%)	Hospital C (%)	Hospital D (%)
Segregation	60	66.67	40	80
On-site transport	57.14	42.85	57.14	42.85
Temporary storage	81.25	100	100	100
Internal treatment	NA*	NA*	NA*	100
Off-site transport	100	100	100	100
External treatment	100	100	100	100
Total	77.78	83.78	83.33	86.48

Note: NA = not applicable because no activities were related to the stream.

for non-infectious waste recycling.

Furthermore, all hospitals implemented a first in, first out (FIFO) system to manage hazardous products, ensuring that they are equipped with stock cards and digital reports to record the inflow and outflow of products. Moreover, stock evaluations are conducted on a monthly basis. However, concerning the procurement of hazardous products, only Hospital C underwent the procurement process, facilitated by a single team operating within the pharmacy storage facility. In contrast, hazardous product procurement in the other three hospitals was carried out by separate teams, depending on the product type (medical and non-medical) and storage requirements. All hospitals also replaced hazardous products by converting mercury healthcare equipment into digital devices and digital radiology activities without red-ink immersion, fixers, or developers. Hospital B replaced the ethylene oxide sterilizer with plasma technology.

*Medical Waste Management Stream*

Medical waste management includes segregation, on-site transport, temporary storage, internal treatment, off-site transport, and external treatment. Table 2 presents the percentage of medical waste management implementation in each hospital, based on the observation checklist adhering to the Regulation of the Indonesian Ministry of Environment and Forestry No. P56 of 2015 criteria.

*Waste Segregation*

All hospitals sorted medical waste from their sources, carried out by waste officers involved in activities that

generate it. Hospitals A and C provided medical waste containers, such as safety boxes for sharps waste and yellow plastic bags for all types besides sharps waste. In addition, Hospital A used hemodialysis or laundry jerrycan as safety boxes, although it was not equipped with medical waste labels.

Hospitals B and D provided containers, such as safety boxes, yellow plastic bags for infectious and pathological waste, brown plastic bags for pharmaceutical and chemical waste, and purple plastic bags for cytotoxic waste. Generally, plastic bags are placed in a secured bin and contain an information sticker describing the type and details of the medical waste. Hospitals C and D also established separate waste bins for recycling uncontaminated infusion plates.

Regarding the symbols and labels on plastic bags, Hospitals A and C did not provide yellow bags with infectious symbols and purple bags with cytotoxic symbols. In contrast, Hospital A provided plastic bags symbolizing infectious waste, and Hospital D provided a label indicating the type of medical waste attached to the bags.

*On-site Transport*

Regarding on-site transport of medical waste, only Hospital B handled medical and non-medical waste simultaneously using the same trolley without separate compartments. In contrast, other hospitals separately transported medical and non-medical waste using different transport schedules. Medical waste in Hospitals A, B, and C was transported every morning and afternoon. Hospital D transported medical waste at least once a day,

depending on the needs of each room and the amount of medical waste produced. Only Hospital B had a designated medical transportation route. However, certain waste officers at Hospital B transported medical waste using an elevator. In contrast, other hospitals transported medical waste using the same route as the patients and visitors. Additionally, all hospitals normally transport medical waste after transporting food to patients or not during visitor hours.

All hospitals used the same equipment for transport facilities: a wheeled trolley with a top cover, handgrip, and foot stomp to open the cover. However, none of the trolleys contained labels or symbols related to medical waste. Only Hospitals C and D cleaned their trolleys daily for trolley washing and disinfection activities. Hospitals A and B performed cleaning once a month and every two days for one week, depending on the physical condition of the trolley. In addition, the medical waste plastic bag ties in Hospitals A and C were all single ties, whereas some medical waste plastic bags in Hospitals B and D had bunny ear ties.

#### *Temporary Storage*

All hospitals had temporary medical waste storage licensed by the Bogor District Environmental Office. Hospital C had technical specifications that have become new licenses for hazardous waste storage. Hospital A had a 20'x6m container-shaped medical waste temporary storage as a form of cooperation with off-site transport services. However, the medical waste plastic bags were put on the floor because of the limited number of trolleys. In contrast, three other hospitals had separate buildings behind the hospital's main building in the form of partitioned/separated rooms for different types of medical waste and an adequate number of trolleys for medical waste plastic bags far from food supply and storage.

Hospitals A, B, C, and D had waterproof floors and flat surfaces. Water faucets, personal protective equipment (PPE), and medical waste containers were in or near the storage. Temporary storage contained hazardous symbols that officers could lock. The location was accessible to transport vehicles and waste trolleys, and there were no signs of animals or insects within the storage area. However, Hospital A lacked cleaning equipment and ventilation. In addition, Hospital A had an unsafe waste storage container cantilever that could cause accidents and falls, and the location was in an open space, which posed challenges to waste transportation when it rains.

Regarding the temporary storage cleaning schedule, Hospitals B and D cleaned their floors daily. Hospitals A and C cleaned the floor thrice a week after disposing of waste through a transporter to the external waste treatment plant. All hospitals temporarily stored the medical

waste according to an off-site transport schedule. Pathological waste from Hospital D was stored in a sealed box with formalin and partially inside a refrigerator for up to three months. While, in Hospital B, pharmaceutical and cytotoxic waste was stored for a maximum of three months in a locked room within the pharmacy storage area. This precaution was taken to enhance the security of the drug waste before it was processed following the waste consignment flow mandated by the Bogor District Government.

#### *Internal Treatment*

All hospitals did not treat their medical waste independently. Hospitals A and C lacked waste treatment technologies. Hospital B had an incinerator, but it could not be used because it was still in the licensing process. Hospital D had a licensed incinerator; however, its activity was deactivated for maintenance in October 2022. While the incinerator was operational, Hospital D always performed gas emission and soil quality tests every six months, and the outcomes consistently demonstrated compliance with the specified limit for each tested parameter. Additionally, Hospital D collaborated with a licensed external party to manage the storage of residual ash resulting from the incineration process.

#### *Off-site Transport*

All hospitals collaborated with external waste transport services to deliver their medical waste from temporary storage in the hospital to an external hazardous waste treatment plant. Hospital A partnered with Company E; Hospitals B and D partnered with Company F; and Hospital C partnered with Company G. All these external parties had a license recorded in the Indonesian Ministry of Environment and Forestry and a four-wheel vehicle licensed from the Directorate General of Land Transportation. The waste transport schedules in Hospitals A, B, and C were held every Mondays, Wednesdays, and Fridays; whereas, Tuesdays, Thursdays, Saturdays, and Sundays were for Hospital D. However, Hospital B could transport their waste on Sunday if they arrange an appointment with the transporter.

The vehicle used was a four-wheeled box car with a separate room between the driver and the medical waste. The waste storage room was securely locked, had a company identity, an emergency number, and a hazardous waste symbol on the vehicle's body. Off-site transport begins with weighing and documenting the amount of medical waste. The next step was transporting medical waste inside the vehicle. Finally, both the hospital officer and transporter completed the waste consignment form before departing. Off-site transport was tracked and documented in a digital manifest (festronic) released by

the Indonesian Ministry of Environment and Forestry. In addition, the monthly balance sheet of medical waste generated and transported by the external transporter in each hospital showed no difference between the waste entering temporary storage and that being transported by the off-site transport service.

*External Treatment*

All hospitals collaborated with external hazardous waste treatment services through bipartite and tripartite agreements. Hospital A partnered with Company H, while Hospitals B, C, and D partnered with Company G. External companies obtained technical approval for hazardous waste treatment from the Indonesian Ministry of Environment and Forestry. They were also responsible for storing and treating the medical waste in the treatment facilities under national regulations, disposing of ash after treatment, documenting the related processes, and reporting activities using the same digital manifest as the off-site transport electronic.

*Policy and Standard Operational Procedures*

All the hospitals had specific policies related to hazardous waste management, including medical waste, in the form of directors' decisions (Table 3). Generally, the policies include the type and source of medical waste, medical waste management streams, and personal protection guarantees. In addition, all the hospitals had several SOPs related to medical waste management in their hospital area. Overall, these SOPs contained information about the definition of each SOP, purpose, related regulations, procedures, and units related to every SOP.

*Human Resources Quality*

Hospitals B and C trained all health personnel on medical waste management. The training, referred to as In-House Training, is conducted once a year with two speakers: one from the hospital's environmental health officer

and the other is a certified person from an external party collaborating with the hospital. The In-house Training included hazardous waste management, proper securing of waste bags, and the management of hazardous material spills. Only new employees at Hospital A received education and training in medical waste management, unlike at Hospitals B and C. While, approximately 75% of Hospital D employees in medical waste management received basic training.

*Finance*

All hospitals planned separate budgets for medical waste each year. In general, hospital expenses for medical waste management included third-party services (off-site transportation and treatment), the supply of medical waste containers, PPE, hygiene procurement, and labels for waste bins. In addition, Hospital D incurred other expenses, such as maintenance costs for the incinerator. These expenses were determined and assigned appropriate account numbers as necessary.

*Facilities and Infrastructure*

Medical waste management in each hospital provided health personnel with complete PPE, including helmets, uniforms, head caps, aprons, goggles, rubber gloves, safety shoes, and masks, to process medical waste. However, some personnel did not use the PPE appropriately. Furthermore, waste transportation equipment and medical waste containers were provided by all hospitals, including wheel bins, medical waste plastic bags, and plastic bag waste bins. All hospitals had temporary medical waste storage facilities. Hospitals B and D obtained a new temporary storage license, Technical Specifications, for hazardous waste management. This was prompted by the limited space available for temporary storage in Hospital B. Notably, Hospital D had recently expanded its temporary storage capacity.

**Table 3 Availability of Medical Waste Standard Operational Procedures**

Standard Operational Procedure	Hospital A	Hospital B	Hospital C	Hospital D
Waste segregation	✓	✓	✓	✓
Insite transportations	✓	✓	✓	✓
Temporary storage	✓	✓	✓	✓
Off-site transportation	✓	✓	✓	✓
Medical waste treatment and disposal	✓	✓	✓	✓
COVID-19 waste management	✓	✓	✓	✓
Handling hazardous material	✓	✓	✓	✓
Main tasks, job description, and responsibilities of waste officer	-	✓	-	-
Hazardous waste labelling	✓	✓	✓	✓
PPE utilization	✓	✓	✓	✓
Medical waste recycling management	-	-	-	✓
Medical waste report	-	✓	✓	✓

**Notes:** COVID-19: coronavirus disease 2019, PPE = Personal Protective Equipment

## Discussion

### *Reduction of Solid Medical Waste*

According to the Regulation of the Indonesian Ministry of Environment and Forestry No. P56 of 2015, the reduction of medical waste can be carried out by using the reuse, reduce, and recycle approach.<sup>13</sup> However, the process must be accurately executed through thorough cleaning and disinfection of waste packaging, infusion bottle waste, hemodialysis fluid packaging, and syringes before recycling and reusing.<sup>13</sup> Hospital A did not adhere to these standards before reusing hazardous waste.

Cleaning, decontamination, disinfection, and sterilization methods may be employed to reuse medical waste, while some types of jerry cans can be reused after cleaning and disinfection.<sup>14</sup> Only Hospital C met the standard of centralized hazardous product procurement. Centralized hazardous procurement aims to reduce unnecessary purchasing, improve product inflow and outflow monitoring, and ensure compliance with waste reduction regulations.<sup>16</sup> All hospitals comply with the regulations by implementing the FIFO system and replacing hazardous goods with safer products.

### *Waste Segregation*

All hospitals met the standards of the Regulation of the Indonesian Ministry of Environment and Forestry No. P56 of 2015,<sup>13</sup> for sorting medical waste as closely as possible to the source of the waste. However, Hospitals A and C did not meet the criteria because they did not supply brown plastic bags for pharmaceutical and chemical wastes, despite hospitals rarely producing these wastes. In addition, Hospitals B and C also did not meet the standards because there were no symbols for waste bags. Waste segregation must be carried out according to medical waste characteristics with proper color codes and labeled waste containers to ensure that waste separation can continue until the end of waste management.<sup>15</sup> Moreover, the goal of segregation is to identify different types of medical waste, mitigate the risk of personnel exposure to hazardous medical waste, and reduce costs associated with the treatment and disposal of medical waste.<sup>17</sup>

### *On-site Transport*

All hospitals met the requirements of the Regulation of the Indonesian Ministry of Environment and Forestry No. P56 of 2015.<sup>13</sup> This involves regularly transporting waste from the source to temporary storage at least once a day or when the plastic waste bag is  $\frac{3}{4}$  full.<sup>13</sup> Moreover, each hospital must be equipped with a wheeled trolley that adheres to established standards, ensuring ease of loading, unloading, and cleaning and possessing durable construction.<sup>13</sup> However, the trolleys in all hospitals

lacked hazardous waste identity labels, hazardous waste symbols, and labels for the lid trolley positions. Furthermore, only Hospitals C and D met the daily cleaning and disinfection requirements for trolleys. The trolleys used must be disinfected using proper disinfectants, such as chlorine, carbolic acid, lysol, or similar substances.<sup>18</sup>

The goal of using separate routes for waste transport is to avoid aesthetic damage and transmission of nosocomial diseases in hospitals.<sup>19</sup> Hospitals A, C, and D did not meet the standard because no separate medical waste transport routes existed. Furthermore, on-site transport should be performed during quiet periods, and specific transportation hours should be established.<sup>20</sup> Regarding the shape of medical waste plastic bag ties, Hospitals B and D did not comply with the requirement, as their plastic waste exhibited bunny ear-tie shapes. According to the regulations, the tie shapes of bunny ears, tying with tape, and leaving the bag open are prohibited.<sup>15</sup> This prohibition is in place to prevent the risk of waste spillage during transportation to the waste treatment plant.<sup>27</sup>

### *Temporary Storage*

All the hospitals complied with the regulations regarding the availability of permits and the construction of temporary storage.<sup>13</sup> Hospital C already has a new permit, per the new government regulation, where licenses for temporary hazardous waste storage are now issued in the form of technical specifications.<sup>21</sup> Under these regulations, building construction and container facilities are deemed suitable for temporary storage of hazardous waste.<sup>22</sup> Regarding the adequacy of facilities at temporary storage, only Hospitals B, C, and D met the regulatory requirements. Hospital A did not comply with certain requirements, such as the availability of cleaning equipment near storage and inadequate precautions against potential hazards. Hospitals are responsible for providing temporary storage with good lighting, PPE, cleaning equipment, waste containers near the storage site, appropriate symbols and signs of hazards, and limited access that can be locked.<sup>23,24</sup> Hospitals B and D were the only hospitals that met the standard of the temporary storage cleaning routine, as they cleaned these facilities daily.

Furthermore, Hospitals A, B, and C still did not meet the regulatory requirement regarding storage duration because the transportation schedule from Friday to Monday exceeded two days for storing infectious, pathological, and sharps waste. In addition, Hospital D did not comply with the provision for storing pathological waste for up to three months without a coolbox. The Regulation of the Indonesian Ministry of Environment and Forestry No. P56 of 2015 states that infectious, sharps, and pathological waste should be stored in temporary storage for a maximum of two days at  $>0^{\circ}\text{C}$  or 90 days at  $<0^{\circ}\text{C}$ . In contrast, chemical, cytotoxic, and pharmaceutical waste

can be stored for up to 90 days if it weighs >50 kg and up to 180 days if it weighs <50 kg.<sup>13</sup> The time limits for storing medical waste in temporary storage serve to minimize the growth of pathogens, decomposition, and odors.<sup>23</sup>

#### *Internal and External Treatment*

Hospital D complied with the regulations regarding waste treatment because it already had a permit from the Indonesian Ministry of Environment and Forestry to process medical waste using an incinerator. Incineration is the process of burning hazardous waste at high temperatures to eradicate toxic and hazardous substances using an incinerator.<sup>25</sup> The temperature range in an incinerator is around 1,600–2,500°F, and the process takes about 30 to 90 minutes. The burning process of an incinerator must eliminate at least 99.99% of the pollutants in the waste, and the residual ash from these activities is disposed of in sanitary landfills.<sup>25</sup>

All hospitals complied with the regulation,<sup>13</sup> by collaborating with licensed stakeholders, supported by written agreements. Furthermore, external waste treatment activities were guided by the same manifest as the off-site transport activities. Several factors must be considered when conducting waste treatment with external parties. The chosen external parties must have permission from the government, be able to manage medical waste treatment and disposal according to relevant regulations, and hold a consignment for the arrival of medical waste.<sup>14</sup>

#### *Off-site Transport*

Waste transporters are required to hold a permit for hazardous waste transport activities.<sup>13</sup> All hospitals complied with the standard because they collaborated with waste transport companies with government permits, including permits for hazardous waste delivery vehicles. In medical waste management, external transportation is usually outsourced to third parties.<sup>26</sup> Therefore, it is imperative to establish a written agreement outlining every operational detail; moreover, regular monitoring is essential to ensure that the activities align with the stipulated regulations.<sup>26</sup> Furthermore, the specifications of the medical waste transport vehicles and the manifests in the hospitals conformed to established standards.

#### *Policy and Standard Operational Procedure*

All hospitals had specific policies and SOPs concerning the management of solid medical waste. It is imperative to establish a comprehensive medical waste management policy for the sustained effectiveness of medical waste management.<sup>26</sup> This policy should align with national regulations and facilitate collaboration with stakeholders.<sup>28</sup> Furthermore, well-defined SOPs are essential to optimize the efficiency and accuracy of medical waste

management activities.<sup>29</sup>

#### *Human Resources Quality*

According to the Regulation of the Indonesian Ministry of Environment and Forestry No. P56 of 2015, all personnels involved in hazardous waste management must have received proper training.<sup>13</sup> Hospitals A and D did not meet the standard because they have not adequately trained all human resources in medical waste management. The training seeks to enhance the understanding of health, safety, and environmental issues associated with medical waste. This will empower workers to conduct appropriate practices and understand their roles in sustainable medical waste management.<sup>30</sup>

#### *Finance*

All hospitals had annual budget plans for medical waste management. Budget planning is conducted following fund allocation from the government budget. Funds allocated for medical waste management are key to ensuring that medical waste management activities are carried out effectively and sustainably.<sup>31</sup> Medical waste management costs are separated into investment and operational costs.<sup>24</sup> The investment costs expended by these hospitals included PPE (uniforms, helmets, and safety shoes). Operational costs encompassed various items, including disposable PPE (head cap, mask, gloves, and apron), cleaning supplies, medical waste container procurement, equipment maintenance, and third-party vendors.

#### *Facilities and Infrastructures*

All hospitals complied with the regulation,<sup>13</sup> regarding the availability of PPE and the physical conditions of transport equipment. However, Hospitals A, B, and C did not meet the standards for medical waste containers or medical waste bag symbols. Furthermore, all hospitals had licensed separate buildings and containers for temporary medical waste storage. The old license for temporary storage has a five-year renewable term and can be extended.<sup>29</sup> However, there was an adjustment in the permit process according to the most recent laws, which is permanently valid unless temporary storage is changed. The most recent permits are in the form of technical specifications for storing hazardous waste.<sup>32</sup>

#### **Conclusion**

Based on the availability of solid medical waste management reporting activities, permits related to temporary storage for medical waste ownership, and collaboration with licensed external parties that officially have government permits to manage solid medical waste indicate that all hospitals adhere to the regulatory standards. The recommendations for all hospitals are providing ade-



quate SOP for reduction activities, providing plastic bags with appropriate color codes and symbols as well as an adequate number of medical waste trollies, equipping the emergency facilities with temporary storage, and providing comprehensive training on medical waste management to all medical waste personnel.

#### Abbreviations

WHO: World Health Organization; SOP: Standard Operational Procedure; FIFO: First In First Out; PPE: Personal Protection Equipment.

#### Ethics Approval and Consent to Participate

This study was approved by the Research and Community Engagement Ethical Committee of the Faculty of Public Health, University Indonesia, with number: Ket- 91/UN2.F10.D11/PPM.00.02/2023. Written informed consent was obtained from all participants.

#### Competing Interest

The authors declared no significant competing financial, professional, or personal interests that may affect the performance or presentation of the work described in this manuscript.

#### Availability of Data and Materials

All data and materials from this study can be given by the primary author.

#### Authors' Contribution

SK designed the study, developed the instrument, performed the data analysis and interpretation, and drafted the manuscript; AK, DS, and UTS reviewed the manuscript, advised on the data analysis and interpretation, and contributed to proofreading.

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