Evaluation of hospital infectious waste management (HIWM) implementation based on applicable regulations in Bandung

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Abstract. Infectious waste from health facilities has been characterized to be a hazardous waste that required a proper management. However, the implementation of infectious waste management in healthcare facilities has been conducted improperly and caused infectious diseases spread in developing countries. Some studies that have developed on infectious waste management were qualitative in nature, and it has not yet been measured the percentage value of hospital infectious waste management was in accordance with applicable regulations. The higher percentage value, showed the better management and handling of infectious waste in a hospital. The aim of this research was to evaluate the percentage value of hospitals infectious waste management (HIWM) compliance with Indonesian regulation of HIWM. The data were obtained from 7 hospitals in Bandung area, with checklist method according to the Minister of Environment Regulation No. p.56, 2015. The standard checklist of regulation consist 9 process of HIMW such as: (1) standard operational procedure (SOP); (2) Segregation; (3) Collection; (4) Transport; (5) Storage; (6) Monitoring of generation infectious solid waste/weighing; (7) Human resources due to preventive action/worker protective; (8) Contingency plans; and (9) Disposal process, from 9 HIWM process contain 63 items standard of HIWM. From the analysis data, it was known that the percentage of compliance of the HIWM to the regulation was not caused by the type of hospital and the type of hospital ownership significantly, but rather focuses on the HIWM management process. From 7 hospitals in Bandung area, the compliance only meets 58.5 % comparing to 100 % assessment score. ANOVA analysis showed the types of hospital gave the significant effect on percentage values of HIWM (p < 0.05). It is proposed that every hospital should make some evaluations for the hospital infectious waste management to improve the quality of HIWM.

Keywords: handling infectious waste, standard regulation, HIWM, ANOVA test

1. Introduction
Waste from health facilities was divided into two categories, non-hazardous and hazardous waste. Infectious waste based on Indonesia government regulation includes as hazardous and toxic waste [1]. Exposure to hazardous health service waste can result illness or injury. The dangerous nature of the health service waste is possible arises from following characteristics: waste containing agents infectious, genotoxic waste, waste containing chemicals or drugs dangerous or toxic, waste is radioactive, waste contains sharp objects. The hospital is a service centre that generates the most
medical waste with 120 kg/day, when compared to other health facility centres such as community health service centre with 70 kg/day and 71 kg/day clinical pathology [2] and annually hospital waste also increased almost twice in two years [3]. According to [4,5] infectious waste is characterized as hazardous and toxic waste that required proper management. However, management of infectious waste from health facilities 18 % - 64 % of the generation of hospitals infectious waste in development countries are not managed properly in every stage of managing infectious waste [6].

Preview study on [7] showed that HIWM in Bandung area based on Environmental Protection Agency (EPA) standard, the compliance only meets 57 % from 100 % assessment score. Thus, provide evidence that the implementation of infectious hospital waste management in the Bandung area has not been done properly, in accordance with applicable procedures or regulations. However, the assessment was carried out by comparison to international regulations EPA, 1992. Based on UU No.44 of 2019, hospitals in Indonesia are divided into two groups of services: (1) general hospitals; (2) specialized hospitals. Whereas based on the type of hospital divided into 4 types: (1) type A; (2) type B; (3) type C; and (4) type D. The difference between the four types of hospitals was the medical service units available. In this study, we improved the instrument which used to assess the compliance of HIWM practice against the regulation based on character and types of hospital.

The standard of the evaluation in this study was Minister of Environment and Forestry Regulation No. p.56, 2015. This regulation contains the latest regulations regarding the management of hazardous and toxic waste in Indonesia. The study that discusses the compliance between the implementation of HIMW to the applicable regulations is still very limited, especially in Indonesia. Therefore, the objectives of this study are directed towards: (1) determine the process or stages of HIWM based on applicable regulation and (2) analyse the suitability of HIWM implementation based on the Ministry of Environment and Forestry Regulation No. p56, 2015.

2. Methods and Materials

2.1. Research framework

Globally, the management of HIWM were significant differences between low, middle and high-income countries [8]. Effective regulation of waste categories are an important factor, especially regarding treatment and disposal in HIWM. There were seven processes of HIWM which has been determined [3], they were include production, classification, packaging, sterilization, weighing, storage and transportation process. However, each country has different regulations in governing their hospital infectious waste and very few studies have been conducted on infectious waste in Indonesia especially in Bandung region that related to assessment of HIWM. Research framework shown Figure 1. According to Indonesian regulation of infectious waste, the HIWM is regulated by the Government, consists: a) segregation, b) collection, c) storage and d) disposal as shown in Figure 2.
2.2. Survey method and data analysis

There are 7 hospitals that gave their research permission on hospital infectious waste management from 20 hospitals in Bandung which asked for research permission, therefore in this study. For data analysis we grouped into two categories based on their services categories: 5 general hospitals and 2 specific hospitals, and based on owner categories: 4 public hospitals (own by government) and 3 private hospitals (own by non-government), shown in Table 1. Hospitals area for study in this research was located in Bandung region. Check list form were made based on Ministry of Environment and Forestry Regulation No. p56, 2015 to collect information on hospital infectious waste management practices. It consists of 63 standard condition including the segregation, collection, cleaning, transportation, storage and disposal. Data analysis used descriptive statistic and Anova two ways methods. The formula to calculated percentage value of suitability HIWM due to Government regulation describe below.

\[
\text{\% compliance} = \left( \frac{\sum \text{Score compliance to regulation}}{63} \right) \times 100 \%
\]

For example, if the hospital has 50 score compliance to regulation, the percentage value of compliance is \((50/63) \times 100 \% = 79.4 \%\). The research method and flow this studi shown in Figure 3. The purpose of giving a hospital code (RS 1 -RS 7) is to maintain confidentiality due to research code of ethics that has been mutually agreed.

Table 1. Hospital selected by group of hospital services.

| Hospital Code | Hospital Services       | Owner/Management | Type of Hospital |
|---------------|------------------------|------------------|-----------------|
| RS 1          | General hospital       | Public           | B               |
| RS 2          | General hospital       | Public           | B               |
| RS 3          | General hospital       | Private          | C               |
| RS 4          | General hospital       | Public           | D               |
| RS 5          | Specific hospital      | Private          | C               |
| RS 6          | General hospital       | Private          | C               |
| RS 7          | Specific hospital      | Public           | A               |
3. Results and Discussions

3.1. Percentage value analysis of hospital infectious waste management

Hospital is a health service institution that conducts complete individual health services that provide inpatient, outpatient and emergency services. After analysing the regulations of the environment and forestry ministries p.56/2015, infectious waste management processes or functional system must be obtained, i.e. (1) management; (2) segregation; (3) collection; (4) transport; (5) sterilization; (6) storage; (7) weighing infectious waste; (8) worker protection; (9) contingency plans; and (10) disposal process. The sterilization process was stipulated in the regulations, but in the implementation of the seven hospitals observed, none of them implemented the sterilization process, so that the waste management process in this study was carried out only nine process exclude the sterilization process. Sixty-three (63) standards were assessed for hospital infectious waste management from 9 identified processes. Percentage count by divided the complied items with total items that observed, the result shown at Table 2.

Table 2. Percentage value.

|                   | RS 1 | RS 2 | RS 3 | RS 4 | RS 5 | RS 6 | RS 7 | Average (%) |
|-------------------|------|------|------|------|------|------|------|-------------|
| Management        | 55.5 | 66.7 | 100  | 44.4 | 77.8 | 77.8 | 66.7 | 69.8        |
| Segregation       | 33.3 | 33.3 | 66.7 | 0    | 33.3 | 0    | 33.3 | 28.6        |
| Collection        | 63.6 | 72.7 | 63.7 | 36.4 | 63.6 | 54.5 | 72.7 | 61.0        |
| Transportation    | 87.5 | 100  | 55.6 | 44.4 | 87.5 | 77.8 | 66.7 | 74.2        |
| Storage           | 52.4 | 80.9 | 80.9 | 9.5  | 71.4 | 57.1 | 66.7 | 59.8        |
| Weighing          | 100  | 100  | 100  | 0    | 100  | 100  | 100  | 85.7        |
| Worker Protection | 66.7 | 66.7 | 100  | 66.7 | 66.7 | 66.7 | 66.7 | 71.5        |
| Contingency Plans | 0    | 66.7 | 66.7 | 0    | 33.3 | 33.3 | 33.3 | 33.3        |
| Disposal          | 50   | 50   | 50   | 0    | 50   | 50   | 50   | 42.9        |
| Average (%)       | 56.6 | 70.8 | 76   | 22.3 | 64.8 | 57.4 | 61.8 |             |
Infectious waste should be sealed in yellow bags and sterilized before weighing. HIW should be stored less than 48 hours after weighing, before transportation by a registered waste disposal company. According to Ministry of Environment and Forestry Regulation No. p56-2015, the sterilization process is the main difference in the treatment of infectious and non-infectious waste. Overall average percentage of compliance between regulations and implementation in the field from 7 hospitals is 58.5 %. The results of the analysis based on the type of hospital give a percentage value 56.6 % and 63.3 % for general hospital and specific hospital respectively. Based on the ownership type (public hospital and private hospital) each give a percentage value respectively 52.9 % and 66.1 %. Graphically, the calculation results of the percentage value of the suitability of the implementation of hospital infectious waste management to the regulation is shown in Figure 4 and Figure 5.

![Figure 4. Percentage value based on hospital services and hospital ownership](image1)

![Figure 5. Percentage value based on type of hospitals](image2)
3.2. F-test and T-test

The purpose of the significance difference analysis is to determine whether the type of hospital and the type of hospital ownership have a significant effect on the percentage value. First the variance test is performed with the F test to analyse the data variance. Analysis of the type hospital shown that the results of F test give a value of $p > 0.05$ (Table 3), the variance of the two data groups is no significantly different so that the analysis of the T-test is continued by assuming that the data variants are equal. T-test results show the value $p > 0.05$ (Table 4), the average difference in the percentage value does not differ significantly, it can be concluded that the type of hospital does not significantly influence the percentage value. Analysis of the ownership hospital shown that the results of F test give a value of $p > 0.05$ (Table 5), the variance of the two data groups is no significantly different so that the analysis of the T-test is continued by assuming that the data variants are equal. T-test results show the value $p > 0.05$ (Table 6), the average difference in the percentage value does not differ significantly, it can be concluded that the ownership of hospital does not significantly influence the percentage value.

### Table 3. F test for hospitals services data group

| Parameter                  | General hospitals | Specified hospitals |
|----------------------------|-------------------|---------------------|
| Mean                       | 56.62             | 63.3                |
| Variance                   | 438.782           | 4.5                 |
| Observations               | 5                 | 2                   |
| df                         | 4                 | 1                   |
| F                          | 97.50711          |                     |
| P(F<=f) one-tail           | 0.075791          |                     |
| F Critical one-tail        | 224.5832          |                     |

### Table 4. T test for hospitals services data group

| Parameter                  | Specified hospitals | General hospitals |
|----------------------------|---------------------|-------------------|
| Mean                       | 63.3                | 56.62             |
| Variance                   | 4.5                 | 438.782           |
| Observations               | 2                   | 5                 |
| Pooled Variance            | 351.9256            |                   |
| Hypothesized Mean Difference| 0                   |                   |
| df                         | 5                   |                   |
| t Stat                     | 0.4256              |                   |
| P(T<=t) one-tail           | 0.344048            |                   |
| t Critical one-tail        | 2.015048            |                   |
| P(T<=t) two-tail           | 0.688096            |                   |
| t Critical two-tail        | 2.570582            |                   |
**Table 5. F test for hospitals ownership data group**

| Parameter          | Public hospitals | Private hospitals |
|--------------------|------------------|-------------------|
| Mean               | 52.875           | 66.06667          |
| Variance           | 449.8892         | 87.69333          |
| Observations       | 4                | 3                 |
| df                 | 3                | 2                 |
| F                  | 5.130255         |                   |
| P(F<=f) one-tail   | 0.167446         |                   |
| F Critical one-tail| 19.16429         |                   |

**Table 6. T test for hospitals ownership data group**

| Parameter                  | Public hospitals | Private hospitals |
|----------------------------|------------------|-------------------|
| Mean                       | 66.06667         | 52.875            |
| Variance                   | 87.69333         | 449.8892          |
| Observations               | 3                | 4                 |
| Pooled Variance            | 305.0108         |                   |
| Hypothesized Mean Difference| 0                |                   |
| df                         | 5                |                   |
| t Stat                     | 0.988971         |                   |
| P(T<=t) one-tail           | 0.184045         |                   |
| t Critical one-tail        | 2.015048         |                   |
| P(T<=t) two-tail           | 0.36809          |                   |
| t Critical two-tail        | 2.570582         |                   |

3.3. *Anova test*

In this study ANOVA tests were conducted. The first ANOVA test was to analyse whether the average suitability value at each hospital is significantly different or not. The second test is to analyse whether there are significant differences between the infectious waste treatment processes that have been identified in seven hospitals. ANOVA two-way test result shown the value of $p < 0.05$ (Table 7), both in HIWM process and hospitals as variable independent. This shows that the average percentage value in each hospital is significantly different either with the average percentage value in each process HIWM. It can be concluded that each hospital conducted different waste management practices in each HIWM process. Some hospitals are good in managing infectious waste and some others still do not comply with applicable regulations.

Based on descriptive statistics it is known that RS 4 provides the lowest average value, because in RS 4 the standard operating procedures are still in the planning stage so that cleaning workers are not aware of the latest regulations regarding hospital infectious waste management. Lack of socialization also affects the skills of cleaning workers in handling infectious waste. Among the hospitals that have been observed, RS 3 give the highest average of percentage value with 76% conformity. Hospital RS 3 has all the standard operational procedures in handling infectious waste. Socialization of regulations and procedures for handling infectious waste was trained to the workers so they can handle infectious waste in accordance with the latest regulations.
HIWM functional system in this study also give significantly different result. The lowest percentage value was segregation process, and the highest percentage value was on weighing process. The segregation of hazardous medical waste based on regulation divided in 4 different colours. Red for radioactive, purple for cytotoxic waste, brown for pathologist waste and yellow for infectious waste, respectively. Implementation at the hospital shows that the seven hospitals did not conducted the established regulations. The hospitals policy assigns that hazardous medical waste is only put in a yellow plastic bag. This activity will automatically categorize all hazardous medical waste into infectious waste, yet the highest percentage value of HIWM was weighing process. In this process every hospital conducted the procedure according to establish regulation except hospital RS 4, they never weigh the generated volume the infectious waste. We analyzed the influenced of type of hospital towards percentage compliance HIWM used ANOVA, and the result shown in Table 8.

Table 7. ANOVA test for hospital functional system

| Source of Variation | SS     | df | MS          | F        | P-value   | F crit |
|---------------------|--------|----|-------------|----------|-----------|--------|
| Between Groups      | 16345.46 | 6  | 2724.244    | 4.587862 | 0.000747  | 2.265567 |
| Within Groups       | 33252.45 | 56 | 593.7937    |          |           |        |
| Total               | 49597.91 | 62 |             |          |           |        |

Table 8. ANOVA test for Type of hospital

| Source of Variation | SS     | df | MS          | F        | P-value   | F crit |
|---------------------|--------|----|-------------|----------|-----------|--------|
| Between Groups      | 0.277954 | 3  | 0.092651    | 15.92748 | 0.005432  | 5.409451 |
| Within Groups       | 0.029085 | 5  | 0.005817    |          |           |        |
| Total               | 0.30704 | 8  |             |          |           |        |

Based on statistical calculations the results show that the type of hospital gives a significant difference. According to [9] hospital service units affect the generation of medical waste, because every medical action will cause medical waste with different material, the number of service units owned by hospitals will affected the performance of their medical waste management. Factors that influence the suitability of medical or infectious waste management in a country were knowledge of cleaning services staff, level of awareness, cultural, social and economic [10].

4. Conclusion

Based on this research, it can be taken an outline that functional system HIWM and type of hospital can affect the implementation of infectious waste management significantly. The smaller the percentage value, the more standard operating procedures that are not conducted properly by the hospital. This situation gives an impact on the risk of the hospital infectious waste management. The smaller the percentage value, create the greater value risk to worker health, environment and other social impact.

The data reveal that from 63 items Minister of Environment Regulation No. p.56, 2015 standard of HIMW, generally hospitals in Bandung region only meet 58.5% from 100% assessment score, showed that HIWM still conducted improperly in Bandung region. Type and ownership hospitals did not give significantly influence to the average percentage value, because each hospital has a unique character and requires different treatment until it can achieve 100% compatibility. Each HIWM process gives different results and significantly influences the percentage value, this data can be
developed into a risk assessment basis, and priority can be taken to improve HIWM performance and reduce the risk.

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