# Instrument Development to Measure the Medical Waste Management Performance in Healthcare Centers, Bandung, West Java

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## Abstract

**BACKGROUND:** Medical waste produced by healthcare centers needs to be managed according to the requirements to prevent disease transmission and environmental pollution. An instrument is required to assess the performance of healthcare centers in Indonesia in managing their medical waste.

**AIM:** This study aims to develop an instrument to assess medical waste handling performance indicators in Indonesia's healthcare centers (Puskesmas).

**METHODS:** We used qualitative and quantitative methods to ensure performance indicator instruments' validity, reliability, and quality. Data samples were taken from 70 healthcare centers in Bandung city. The performance assessment tools were created using 20 indicators, taking into account the instrument's validity and reliability.

**RESULTS:** Results revealed that medical waste management's performance in healthcare centers in Bandung was under the good category (60.0%). The best waste management performance categories were shown by healthcare centers level 1 (100.0), level 2 (66.7%) and level 3 (46.2%), also healthcare centers with Basic Emergency Neonatal Obstetrics Services (PONED) services (100.0%). Our results showed that financial, storage and healthcare with PONED services correlate with the amount of medical waste managed.

**CONCLUSIONS:** The instrument developed can be used to assess, monitor, and evaluate medical waste management performance in healthcare centers and become part of healthcare centers' accreditation.

## Introduction

The generated medical waste in Indonesia is predicted to be 1–2% of the overall waste produced [1]. On a global scale, healthcare facilities contributed 15% of medical waste [2]. In Taiwan, generated medical waste reached 3.97 kg/bed/day. In Greece, 30 hospitals and 1427 healthcare centers contributed up to 3350 tons of annual medical waste [3]. In Indonesia, medical waste generated from health facilities, especially hospitals and healthcare centers, reaches 296.86 ton/day [4].

Medical waste can cause various health problems, for example, risk of being infected, wound caused by sharp materials, and poisoning. Besides that, medical waste can harm the environment and the ecosystem. For instance, toxic contamination of dioxin and purin resulted from incinerator burning of medical waste [2], [5], [6], [7], [8]. In 2018, the three biggest rivers in West Java (i.e., Citarum, Cisadane, and Ciliwung) were reported to be contaminated by medical waste [9].

The total capacity of medical waste treatment facilities in Indonesia is 314.29 ton/day, which consist healthcare facilities treatment of 70.21 ton and B3 waste treatment services of 244.08 ton [10]. Yet, an adequate waste treatment facility cannot guarantee that all medical waste can be managed well. Up to this moment, there are still cases where waste was found in an improper environment. Throughout 2014-2018, there were 65 cases related to medical waste, with the highest case located in West Java province (25 cases; 38.46%) [11].

There are 10,134 healthcare centers in Indonesia that potentially generate medical waste [12]. Even though healthcare centers generate less medical waste than hospitals, proper waste management is still needed. As an example, the overall medical waste generated in Surabaya city, East Java, is 163.9 ton/month that consist of 97.1% (158 ton/month) from hospitals, 0.67% (1.1 ton/month) from healthcare centers [13]. West Java province has the highest number of healthcare centers in Indonesia compared to other provinces. Bandung is the city with the highest number of healthcare centers in West Java.

Problems with the medical waste treatment can be related to the performance of the medical waste management itself. Thus, performance assessment or an authentic, multidimensional evaluation of the actual situation is needed. The assessment can be done

through integrated and simultaneous observations and process evaluations showing skills, attitudes, and products [14]. A performance indicator is an instrument to monitor and evaluate important governance and management supporting healthcare services [15]. Medical waste treatment performance indicators from healthcare centers can be developed using input system (structure), process, and output approaches [16], [17].

This study aims to develop a performance indicator instrument on medical waste management in healthcare centers using input, process, and output approaches to obtain a valid and reliable instrument. This study will describe the performance and amount of medical waste managed, also investigate the impact of the medical waste management performance on the number of managed medical waste.

## Materials and Methods

This study was done using quantitative and qualitative approaches. We interviewed ten informants from public health office (Dinas Kesehatan), public environment and sanitary office (Dinas Lingkungan Hidup dan Kebersihan), and head of healthcare centers of Bandung city. Data were gathered through in-depth interviews and observations to be further analyzed using content, matrix, and triangulation analyses. The quantitative approach was done to obtain information on the indicator that will be used to evaluate the performance of the medical waste management. Next, compiled instruments were cross-sectionally distributed to 70 healthcare centers in Bandung city. The interview results were analyzed quantitatively to produce performance indicators of medical waste treatment in healthcare centers. This performance indicator comprises management, steps involved in treating medical waste, and output of medical waste treatment. Each variable includes indicators and parameters.

Before being distributed to healthcare centers, compiled instruments were tested for their validity and reliability. An instrument is categorized as valid and reliable when fulfilling certain criteria, that is, correlation value ≥0.3, Cronbach's alpha ≥0.7. Confirmatory analysis factor requires KMO value, antiimage correlation, communality, and factor loading ≥0.5 to be considered valid and reliable. Next, the instrument was scored based on their input correlation and process to their output. The calculation was done proportionately.

The next step involved calculating minimum and maximum performance scores on each variable and total variables tested. The performance score was grouped as very low (<20%), low (20–39%), adequate (40–59%), good (60–79%), and excellent (≥80%).

## Results and Discussion

Based on the qualitative study, several performance indicators on medical waste treatment in healthcare centers were identified (Table 1). These performance indicators were grouped into three main stages, that is, input, process, and output. Each group consisted of several variables that were measured through several indicators. In this study, there were 11 variables and 17 indicators.

**Table 1: Performance indicator on medical waste management in healthcare centers**

| Variables | Indicators |
|---|---|
| Input | |
| Law aspect | 1. Law/regulation/legislation/SOP |
| | 2. Regulation on reward and punishment |
| | 3. The involvement of law enforcer on law inforcement |
| Institutional aspect | 1. Document plan |
| | 2. Organization and principal duties and functions on waste management |
| | 3. Responsible personnel on medical waste management |
| Financial aspect | Operational costs and investation in medical waste management in the healthcare center |
| Technical aspect | Facilities and infrastructure of medical waste management in healthcare centers |
| Stakeholder aspect | 1. Involvement of public health office and public environment and sanitary office |
| | 2. Financial/infrastructure aid from public/private |
| Process | |
| Sorting and reducing aspect | Medical waste sorting and reducing activity and storage |
| Collection aspect | 1. Ways to collect medical waste |
| | 2. Collecting period of medical waste |
| Storage aspect | 1. Medical waste storage |
| | 2. Container color |
| | 3. Labeling and giving specific symbols |
| | 4. Storage duration |
| Transportation aspect | Complete document and permission to transport medical waste |
| Extermination aspect | Complete document and permission to exterminate medical waste |
| Output | |
| Medical waste aspect | Appropriateness of medical waste management |

### The performance indicator of medical waste treatment in healthcare centers

Medical waste treatment performance indicator in healthcare centers was obtained by applying instruments distributed to 70 healthcare centers in Bandung city. More than half of the healthcare centers (60%) showed an adequate performance, 34.3% showed good performance, and the rest showed low performance (Table 2). The highest values and category score of input indicator were, that is, low in the law aspect (58.6%), good in institutional aspect (57.1%), very good in financial aspect (57.1%), low in technical aspect (60%), and adequate in stakeholder aspect (42.9%). In process indicator, the highest values and category score were good in sorting and reducing aspect (50%), very low in collection aspect (98.6%), good in storage aspect (70%), very good in transportation aspect (54.3%), and good in extermination aspect (60%). In output indicator, most medical waste aspect is in category good (60%).

The performance of medical waste treatment based on the healthcare center characteristics is shown in Table 3. All healthcare centers accredited

**Table 2: Indicator grouping of medical waste management performance**

| Variables | Very low | | Low | | Adequate | | Good | | Very good | |
|---|---|---|---|---|---|---|---|---|---|---|
| | n | % | n | % | n | % | n | % | n | % |
| Total Performance | 0 | 0 | 4 | 5,7 | 42 | 60.0 | 24 | 34,3 | 0 | 0 |
| Input | 0 | 0 | 30 | 42.9 | 37 | 52.9 | 3 | 4.3 | 0 | 0 |
| Law aspect | 24 | 34.3 | 41 | 58.6 | 4 | 5.7 | 1 | 1.4 | 0 | 0 |
| Institutional aspect | 5 | 7.1 | 3 | 4.3 | 19 | 27.1 | 40 | 57.1 | 3 | 4.3 |
| Financial aspect | 5 | 7.1 | 6 | 8.6 | 7 | 10.0 | 12 | 17.1 | 40 | 57.1 |
| Technical aspect | 23 | 32.9 | 42 | 60.0 | 1 | 1.4 | 4 | 5.7 | 0 | 0 |
| Stakeholder aspect | 9 | 12.9 | 26 | 37.1 | 30 | 42.9 | 5 | 7.1 | 0 | 0 |
| Process | 0 | 0 | 1 | 1.4 | 34 | 48.6 | 35 | 35.0 | 0 | 0 |
| Sorting and reducing aspect | 0 | 0 | 13 | 18.6 | 22 | 31.4 | 35 | 50.0 | 0 | 0 |
| Collection level | 69 | 98.6 | 1 | 1.4 | 0 | 0 | 0 | 0 | 0 | 0 |
| Storage aspect | 6 | 8.6 | 9 | 12.9 | 49 | 70.0 | 6 | 8.6 | 0 | 0 |
| Transportation aspect | 0 | 0 | 0 | 0 | 0 | 0 | 32 | 45.7 | 38 | 54.3 |
| Extermination aspect | 0 | 0 | 0 | 0 | 23 | 32.9 | 13 | 18.6 | 34 | 48.6 |
| Output Medical waste aspect | 0 | 0 | 0 | 0 | 3 | 4.3 | 42 | 60.0 | 25 | 35.7 |

as excellent (paripurna; level 1) have demonstrated good medical waste treatment performance (100%). Healthcare centers accredited as level 2 (utama) have mostly shown good performance (66.7%). Healthcare centers accredited as level 3 (madya) has shown mostly good performance (45.2%). Meanwhile, level 4 (dasar) healthcare centers demonstrated good performance of 20%. All healthcare centers which were not yet accredited shown adequate level of medical waste treatment performance (100%).

**Table 3: Medical waste management performance based on healthcare center's characteristics**

| Healthcare center's characteristics | Medical waste management performance | | | | | | Total |
|---|---|---|---|---|---|---|---|
| | Low | | Adequate | | Good | | |
| | n | % | n | % | n | % | |
| Accreditation level | | | | | | | |
| Level 1 (Paripurna) | 0 | 0 | 0 | 0 | 2 | 100 | 2 |
| Level 2 (Utama) | 0 | 0 | 2 | 33,. | 4 | 66.7 | 6 |
| Level 3 (Madya) | 1 | 3.2 | 16 | 51.6 | 14 | 45.2 | 31 |
| Basic level | 3 | 15.0 | 13 | 65.0 | 4 | 20.0 | 20 |
| Un-accredited | 0 | 0 | 9 | 100 | 0 | 0 | 9 |
| Not registered | 0 | 0 | 2 | 100 | 0 | 0 | 2 |
| PONED services | | | | | | | |
| Yes | 0 | 0 | 0 | 0 | 5 | 100 | 5 |
| No | 4 | 6.2 | 42 | 64.6 | 19 | 29.2 | 65 |

PONED: Basic Emergency Neonatal Obstetrics Services.

A good management plan has to be supported by proper planning. Planning has an essential role in an organization. Related to medical waste treatment, good planning on medical waste treatment is necessary [18]. Good medical waste treatment planning covers the organization of clear tasks that were distributed to capable and skillful members appropriate with their field of expertise. Based on the health minister regulation (Permenkes) number 43 year 2019, healthcare centers' medical waste treatment activity is included in the mitigation and eradication of contagious diseases [19]. The quality of the human resources is determined by their obtained educational background and training. Medical staff, nurses, and employees equipped with training on medical waste treatment and related hazards have a high awareness of the risk of medical waste exposure. They can well execute tasks related to medical waste treatment [7], [20].

The financial aspect is related to the fund source and allocation. A clear source of the fund will better facilitate the institution to make a financial plan of activities. Successful activities are the ones supported by financial sources allocated accordingly. As an example, the lack of funding in India has impeded the collection and transportation of solid medical waste [27].

The number of medical wastes managed by healthcare centers in Bandung city can be seen in Table 4. Based on the healthcare center's accreditation level, the highest average of managed medical waste was found in healthcare level 2 (64.95 kg/month). The lowest was found in unaccredited healthcare centers (14.9 kg/month). Healthcare level 2 also shown the highest managed medical waste of 240 kg/month. Medical waste managed by the healthcare centers using Basic Emergency Neonatal Obstetrics Services (PONED) services was higher (mean 116.6 kg/month; median 99.9 kg/month) than healthcare centers without PONED service. The maximum amount of medical waste managed by the healthcare centers was 240 kg/month and most healthcare centers managed 35 kg/month of medical waste as shown by the modus value (Table 4). Based on the performance of medical waste treatment, the highest medical waste managed every month was shown in healthcare centers categorized as good (mean 48.46 kg/month; maximum 240 kg/month).

**Table 4: Monthly average of medical waste managed by healthcare centers in Bandung city**

| Waste managed per month (unit kg) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Medical waste | n HC | Mean | Median | Mod | Min | Max | SD | SE |
| Total medical waste | 70 | 33.78 | 24.25 | 35 | 5 | 240 | 37.63 | 4.5 |
| Based on the healthcare center accreditation level | | | | | | | | |
| Level 1 (Paripurna) | 2 | 64.95 | 64.95 | 30 | 30.0 | 99.0 | 49.43 | 34.95 |
| Level 2 (Utama) | 6 | 69.56 | 30.80 | 18.7 | 18.7 | 240.0 | 85.96 | 35.09 |
| Level 3 (Madya) | 31 | 31.08 | 26.00 | 35 | 5.0 | 130.0 | 25.57 | 4.23 |
| Basic level | 20 | 25.90 | 12.30 | 6 | 5.0 | 125.7 | 29.49 | 6.59 |
| Un-accredited | 9 | 34.01 | 26.00 | 7 | 7.0 | 139.0 | 40.77 | 13.59 |
| Not registered | 2 | 14.90 | 14.90 | 11.5 | 11.5 | 18.3 | 4.81 | 3.40 |
| Healthcare center with PONED service | | | | | | | | |
| Yes | 5 | 111.6 | 99.90 | 35 | 35.0 | 240.0 | 80.04 | 35.80 |
| No | 65 | 27.79 | 22.00 | 15 | 5.0 | 139.0 | 24.83 | 3.08 |
| Medical waste management performance | | | | | | | | |
| Low | 4 | 8.30 | 7.30 | 5 | 5.0 | 13.6 | 3.84 | 1.92 |
| Adequate | 42 | 27.82 | 20.00 | 20.00 | 5.0 | 139.0 | 28.66 | 4.42 |
| Good | 24 | 48.46 | 35.00 | 35.00 | 7.0 | 240.0 | 48.77 | 9.96 |

PONED: Basic Emergency Neonatal Obstetrics Services.

The medical waste treatment activities need to be qualified based on the quantity and quality of every step of medical waste treatment. Must-have facilities in medical waste treatment, that is, sorting container, separated container for non-medical ware, temporary medical waste storage facility, transport facility, and extermination facility. Facility requirements for medical waste treatment are regulated in environmental minister regulation (PermenLHK) number 56 year 2015. In medical waste treatment, stakeholders involved are the ministry of health, the ministry of environment, and the third party.

Sorted wastes were then put in a proper container, labeled, and marked with a specific sign [21]. Several hospitals in Jakarta have not reduced their medical waste through the 3R (reduce, reuse, recycle) method. Recycle process was not done because of several factors, e.g., regulation limitation, potential risk of contamination agents from recycled material, quality control problem, recycle cost related to sorting, and cost on transportation and material processing to the third party [22].

The collection of medical waste should be done using special equipment and transported separately from the non-medical waste. A study by Priya, *et al.* [23] has shown that medical waste should be collected from various rooms using a special trolley, separated from non-medical waste. Medical waste collection from rooms should be done daily or several times per day if the medical waste container in the source room has been filled ¾ part. The collected waste can then be placed in the temporary medical waste facility [24].

All institutions producing medical waste should keep their medical waste in the temporary medical waste facility if it cannot be transported and thrown immediately. These facilities should fulfill several requirements, such as a closed and locked room that can only be accessed by specific personnel but is easy to be accessed by the carrier vehicle during transportation. Medical waste is stored in a temporary facility by storing it in a particular container according to their category and adequately closing it. The container must be filled maximum at ¾ of its original capacity. In the case of leakage and torn containers, a double container should be used to store the waste properly. If the storage period is more than two days, the storage room should be equipped with cold storage facility. Cold storage is helpful to prevent decay and the development of microbial contamination. The requirements of a third party that can handle medical waste treatment are regulated through the ministry of environment regulation (PermenLHK) number 56 year 2015, that is, has a license to transport and exterminate medical waste and has cooperation and manifest agreement [24].

### *The association of input, process, and output indicators and the amount of treated waste*

The input variable of law, institutional, financial, and technical aspects positively affected ($p \leq 0.05$) the amount of managed medical waste. The strength of the relationship measured by the regression's r-value was considered medium (0.25–0.50; Table 5). In the process variable, all shown significant results ($p \leq 0.05$), except the extermination aspect. Meaning, the reducing and sorting, collection, storage, and transportation aspects positively affected the amount of medical waste managed with medium strength (r-value = 0.25–0.5). In the output variable, the medical waste aspect has a medium correlation with the amount of medical waste managed (r-value = 0.301; p = 0.011). Besides that, accreditation of healthcare centers and PONED service has significantly affected the amount of managed medical waste (p < 0.05).

The storage aspect that affected the amount of medical waste managed showed that properly storing medical waste is a crucial aspect that needs to be considered (Table 6). In this case,

**Table 5: Bivariate analysis result on input, process, output and healthcare center's characteristics to amount of medical waste managed**

| Variables | Medical waste management performance | | |
|---|---|---|---|
| | r-value | R²-value (%) | p-value |
| **Input** | | | |
| Lasw aspect | 0.244 | 0.06 (6.0) | 0.042* |
| Institutional aspect | 0.290 | 0.08 (8.0) | 0.015* |
| Financial aspect | 0.429 | 0.18 (18.0) | 0.0001* |
| Technical aspect | 0.288 | 0.08 (8.0) | 0.016* |
| Sxtakeholder aspect | 0.106 | 0.01 (1.0) | 0.84* |
| **Process** | | | |
| Sorting and reducing aspect | 0.459 | 0.21 (21.0) | 0.0001* |
| Collection aspect | 0.320 | 0.10 (10.0) | 0.007* |
| Storage aspect | 0.492 | 0.24 (24.0) | 0.0001* |
| Transportation aspect | 0.247 | 0.06 (6.0) | 0.039* |
| Extermination aspect | 0.114 | 0.01 (2.0) | 0.346* |
| **Output** | | | |
| Medical waste aspect | 0.301 | 0.09 (9.0) | 0.011* |
| **Healthcare center's characteristics** | | | |
| HC accreditation | 0.295 | 0.087 (8.7) | 0.013* |
| PONED service | | | 0.002** |

PONED: Basic Emergency Neonatal Obstetrics Services.

proper storage means the presence of a temporary medical waste storage facility. This storage should be locked and only accessible to specific personnel but accessible to waste vehicles. Medical waste should be appropriately stored in a container with specific color and label. The container can be maximum filled to 2/3 of its capacity, and the upper part should be tied up before being stored in the storing facility. The storing period for infectious medical waste and sharp objects is up to two days at room temperature and can be extended if the facility is equipped with a cold storage room [24].

**Table 6: Multivariate analysis result on input, process, output and healthcare center's characteristics to amount of medical waste managed**

| Variables | Beta coefficient | p-value | R-value | R²-value (%) |
|---|---|---|---|---|
| **Input and Healthcare center's characteristics** | | | | |
| Constant | -84.158 | | 0.622 | 0.387 (38.7) |
| Financial aspect | 2.406 | 0.019 | | |
| PONED service | 77312 | 0.0001 | | |
| **Process and Healthcare center's characteristics** | | | | |
| Constant | -97.925 | | 0.62 | 0.384 (38.4) |
| Storage aspect | 2.856 | 0.022 | | |
| PONED service | 78.27 | 0.0001 | | |

PONED: Basic Emergency Neonatal Obstetrics Services.

Medical waste storage can affect the amount of managed medical waste since all generated medical waste will be stored in the temporary storage facility before being transported to the extermination facility. During the storing period, the amount of medical waste can increase or decrease because of several factors, for example, the temporary storage facility is not separated from non-medical waste, the facility is located outdoors, and the container has the same color as non-medical waste is un-labeled. Those factors can increase the probability of medical waste being mixed with non-medical waste, thus increasing the amount of medical waste. The amount of medical waste can decrease because outdoor storage facilities can give access to others that may collect medical waste with economic value illegally. Another possibility is that medical waste was accidentally thrown as non-medical waste because of un-labeled containers or the container has a similar color to non-medical waste.

The validity and reliability of data collection instruments can guarantee the quality of obtained data. A valid and reliable instrument will ensure the precise instrument is being used to measure indicated needs as valid study data. The use of correlation coefficient to test the instrument validity is commonly used in the instrument development process. For example, a study of Vega *et al.* [25] used coefficient correlation to test the instrument validity for a mechanically functional tool test with an r-value of 0.72–0.98. the Cronbach's alpha coefficient is also widely used to determine the instruments' reliability. Cronbach's alpha is affected by the measurement duration, and measurement needs to be done separately for each concept [26]. In this study, the Cronbach's alpha value was also calculated for each concept.

The scoring instruments used to measure the performance of medical waste treatment in this study can be used in healthcare centers with similar characteristics to this study. The grouping of healthcare centers in Indonesia is based on accreditation and services offered. All accreditation categories and services are covered in samples taken in this study. Therefore, sampled healthcare centers in this study can be considered representatives of all healthcare centers in Indonesia. Hopefully, the scoring instruments on performance of medical waste treatment used in this study can be applied to all healthcare centers in Indonesia.

## Conclusions

Based on the results of this study, a few conclusions can be drawn. This study has successfully produced a valid and reliable set of instruments to measure the performance indicator on medical waste treatment in healthcare centers. Indicators used have comprehensively represented the required management and technical aspect of medical waste treatment in healthcare centers. The overall performance of medical waste treatment of healthcare centers in Bandung city was considered low, adequate, and good. Most of the healthcare centers sampled have an adequate performance on medical waste treatment. Healthcare accredited with levels 1 and 2 has produced more medical waste than other healthcare center accreditation categories. There was more medical waste managed in healthcare centers with a good medical waste treatment category. There was a positive correlation between input, process, and output performances. Variables of indicator performance that influence the amount of managed medical waste were law and storage aspects. The characteristics of healthcare centers affecting the amount of managed medical waste were healthcare with PONED service.

## Ethical Clearance

This study has been reviewed and passed the ethical clearance from Faculty of Public Health Universitas Indonesia with the reference number 22/UN2.F10.D11/PPM.00.02/2020.

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