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RESEARCH ARTICLE

Solid Medical Waste Management Strategy in Hospitals, Indonesia

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Abstract:

The increase in solid medical waste generation has the potential to harm both human health and the environment when not adequately managed.

Objective:

This research aims to identify solid medical waste management strategies in hospitals.

Methods:

This quantitative research uses a cross-sectional study design at the Deli Serdang District Hospital, Sumatra Province, Indonesia. The instrument used to collect data was a questionnaire, and the analysis was conducted using SEM PLS Version 3.3.

Results:

Policies have a significant effect on the behavior of human resources with a p-value of 0.001, and facilities significantly affect the management of solid medical waste with a p-value of 0.001. The waste treatment methods significantly affect the management where the p-value is 0.001. Subsequently, the behavior of human resources has a very significant effect on the management with a p-value of 0.001.

Conclusion:

Policies such as regulatory documents, SOPs, and complete work instructions can establish good behavior. Complete facilities such as trash containers or bins, personal protective equipment, materials for cleaning or disinfection, hazardous and toxic waste (B3) landfills, and waste transportation equipment also play a role in appropriate medical waste management. Additionally, waste treatment methods such as incinerators, autoclaves, and chemical disinfection determine the optimal management of solid medical waste.

Keywords: Solid medical waste, Waste management strategy, Policy, Facility, Waste treatment methods, Hospitals.

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1. INTRODUCTION

The production of hospital solid medical waste at the Kotabumi Indonesia hospital averages 2.0 – 2.8 kg/day [1], and in Deli Serdang Regency is 1.130 kg/day. Hospitals and public health institutions generate 15% of all radioactive, dangerous, and toxic wastes [2]. The Ministry of Health stated that the waste from hospitals in Indonesia is 290 tons/day [3]. The monthly generation of medical waste in Surabaya is 163.9 tons, and only 29.8% is independently processed using an incinerator by health facilities [4]. The percentage of untreated waste is higher than the volume processed, which shows that management requires much more effort and attention and can threaten public health. Moreover, potentially hazardous hospital waste contains asbestos, lead, damp chemicals, adhesives, carbon fluoride, and chlorine [5].

Medical waste in health services, 58 percent of which originates in developing and low-income nations, is disposed of in a dangerous and non-standard manner [6]. In Indonesia, this procedure is not optimal as well. Data from the Ministry of Health stated that the percentage of hospitals that already manage their waste is only 42.58%, where 15.58% is in North Sumatra [7]. Even several first-level health facilities have not yet weighed the volume of solid medical waste generated. Masruddin (2021) argued that every first-level health facility should weigh waste daily to develop an effective management strategy [8].

Previous research stated that managing hazardous and toxic medical waste generally uses open disposal, open burning, incineration, recycling and/or upcycling methods.

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Processing face mask waste by recycling is more useful [9 - 11]. Hayleeyesus (2016) mentioned that waste management in hospitals and public health service centers uses incinerators, no waste segregation based on characteristics, and open dumping [12]. The combustion process also produces solid residues, polluting water and soil. Furthermore, Okeke (2017) added that the combustion process requires a very high cost [13].

Based on the observations, the Deli Serdang Regency Hospital in North Sumatra Province does not reduce and segregate medical and non-medical wastes. Based on plastic bag color standards and waste symbols, waste storage containers' nature and qualities are unsuitable. Likewise, the area for storing Hazardous and Toxic Materials (HTM) waste contained rodents, flies, and insects as vectors. Therefore, planning and managing a solid medical waste system is necessary.

The problem of hospital waste management will be evaluated using a prior study's theoretical framework, explaining that the methods are influenced by five variables, including operational processes, facilities, level of trust, awareness, and training [14]. Ali *et al*. (2017) added that the behavior and types of waste treatment are factors for the success of good management [15]. Based on the problems, it is necessary to develop a strategy in hospitals. Therefore, this research aims to identify a strategy for managing solid medical waste in hospitals to reduce the environmental burden and costs. The results can contribute as a guideline for formulating an effective and efficient solid medical waste management policy.

The resulting strategy is a solution for managing waste according to standards based on the provisions set in Indonesia. The standards that must be implemented by every hospital refer to the Regulation of the Minister of Health of the Republic of Indonesia Number 18 of 2020 concerning Regional-Based Management of Medical Waste in Health Service Facilities.

2. METHODS

2.1. Type and Design

This research is quantitative and uses a cross-sectional study design. It was carried out for 6 months, from July to December 2021, in 3 Deli Serdang Regency type B hospitals. The selection of type B hospitals is assumed to have more complete facilities and services compared to types C and D.

2.2. Population and Sample

The research population comprises nurses, environmental health officers, and cleaning service officers, with 763 people in 3 hospitals. It consists of individuals involved in solid medical waste management, from sorting and decreasing to solid medical waste processing. Meanwhile, the sample size is determined by the Slovin formula which the error tolerance limit is set at 5%; hence it becomes 262 people. The criteria for the sample are determined: 1) willingness to be the research sample. 2) healthy condition, not sick. 3) implementing nurse 4) cleaning officer 5) waste management officer. 360 populations meet the research criteria, and 262 samples are needed, so a simple random sample determines sample selection. Populations not selected in the simple random sample selection technique were not continued as samples.

2.3. Data Collection

Data are collected using a questionnaire based on previous references [2, 14, 15]. Before the questionnaire research, the validity and reliability were tested on 30 respondents. The test results of the questionnaire were declared valid and reliable. Ordinal research variable data scale.

There are 6 variables, namely policy (X1), consisting of 3 indicators, including regulations (X1.1), standard operating procedures (X1.2), and work instructions (X1.3). The waste management facility variable (X2) consists of 5 indicators, namely waste containers or places (X2.1), Personal Protective Equipment (X2.2), cleaning materials (X2.3), and temporary disposal sites for HTM waste (X2.4) and conveyance (X2.5). Meanwhile, behavioral variables (X4) consist of knowledge (X4.1), attitudes (X4.2), and actions (X4.3). The waste treatment methods (X3) are divided into chemical disinfection, incineration, and autoclave. Furthermore, solid medical waste management (Y) is measured by reduction (Y1), storage (Y2), transportation (Y3), processing (Y4), burial (Y5), and stockpiling (Y6).

Solid medical waste management was measured using a questionnaire containing 10 questions, with two answer choices, namely: yes and no. The solid medical waste management measurement category is divided into 2 parts, namely the unsuitable category if the respondent answers the question yes less or equal to 76 percent and the appropriate category if the respondent answers the question yes more than 75 percent.

2.4. Data Analysis

Structural model assessment is through the results of the path coefficient test, goodness of fit test, and hypothesis testing. Testing the relationship path between endogenous or latent variables is conducted by analyzing structural coefficients based on the t-statistical value of 1.96, declared to have a significant effect using Partial Least Square version 3 software. This analysis aims to determine the effect between the dependent and the independent variables with their indicators. The data are the effect of policies on human resource behavior, facilities on solid medical waste management, and human resource behavior on solid medical waste management.

3. RESULTS

Data on the characteristics of research respondents at the Deli Serdang Regency hospital in December 2021 were analyzed in the form of frequency distribution and shown in Table **1**.

The majority of nurses, environmental health professionals, and cleaning service officers, consisting of 160 people or 61.1%, are between the ages of 19 and 32, according to the age breakdown of their characteristics in Table **1**. Based on gender, female workers dominate more, consisting of 164 people or 62.6%. The majority are Associate Degree graduates, with a total of 161 or 61.5%. About 74.8% of 196 people work as

nurses, and based on the years of service, 77.1% or 202 people worked for 1 to 10 years.

The subsequent analysis assesses the path of the relationship between variables (inner model) using the SEM-PLS (Structural Equation Medelling-Partial Least Square) structural equation. But before that, it is necessary to analyze the outer model, namely the analysis of indicators and variables. Following are the results of the outer model analysis, (Fig. **1**).

Table 1. Characteristics of research respondents.

Characteristics	Frequency	Percentage
Age (years)	-	-
19 – 32 Years old	160	61.1
33 – 45 Years old	68	26.0
46 – 58 Yars old	34	13.0
Gender	-	-
Male	98	37.4
Female	164	62.6
Education	-	-
Elementary School	-	-
Junior High School	5	1.9
Senior/Vocational High School	48	18.3
Nursing/Midwifery Associate Degree	161	61.5
Bachelor Degree	47	17.9
Master Degree	1	0.4
Type of work	-	-
Cleaning Service Oficer	52	19.8
Nurse	196	74.8
Environmental Health Worker	14	5.3
Working period (years)	-	-
1 – 10 Years	202	77.1
11 – 20 Years	36	13.7
21 – 30 Years	24	9.2

Note: Source: primary data (2021).

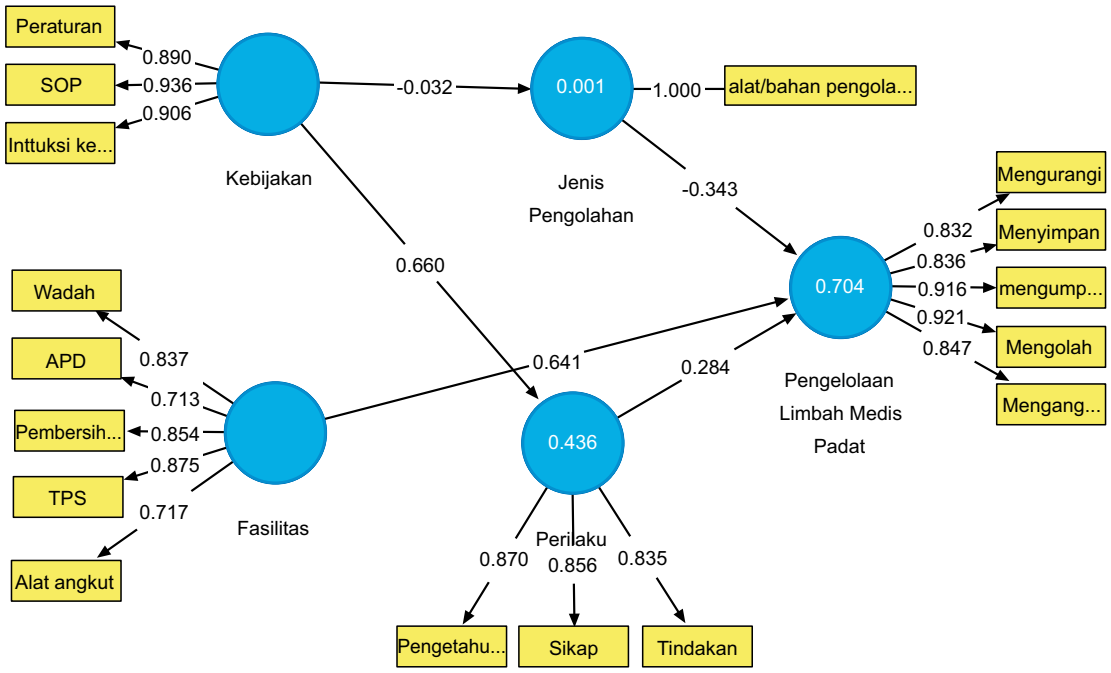

Fig. (1). Measurement of outer model.

Each indicator on the research variable possessing a cross-loading greater than 0.7 will be declared valid and ideal. It can be concluded that the indicators used in this study have good discriminant validity in compiling each of the variables. Based on the above equation, it can be concluded that:

1. The value of the coefficient of effect on the type of treatment is -0.343, meaning that if the waste treatment methods variable increases by 1 percent with the assumption that the variable facility and human resource behavior is zero, then the waste management of solid medical will increase by 0.343 (34.3%). It also shows that the waste treatment methods variable contributes negatively to solid medical waste management.

2. The value of the facility influence coefficient is 0.641, meaning that if the facility variable increases by 1 percent with the assumption that the variable waste treatment methods and human resource behavior are zero, then the management of solid medical waste will increase by 0.641 (64.1%). It also shows that the facility variable contributes positively to solid medical waste management

3. The coefficient value of the influence of human resource behavior is 0.284, meaning that if the behavior variable of human resources increases by 1 percent, assuming the waste treatment methods and facility variable is zero, then solid medical waste management will increase by 0.284 (28.4%). It also shows that the behavioral variables of human resources contribute positively to solid medical waste management.

Table **2** shows that the policy affects behavior and has a t-statistic value of 21.725 > 1.96. This means that the policies set by the hospital will change the behavior of human resources. Furthermore, facilities affect solid medical waste management with a t-statistic value of 11.832 > 1.96. It is concluded that the facilities such as the availability of containers or places for medical waste, waste transport equipment, personal protective equipment, materials or tools for sanitation and disinfection, as well as landfills for B3 waste, will improve the management of solid medical waste to be more appropriate.

Table 2. Path analysis.

Path of Effect	Original Sample	Sample Man	Standard Deviation	T Statistics	P-Value
Policy -> type of waste treatment	- 0.032	- 0.031	0.055	0.579	0.563
Policy -> behavior	0.660	0.665	0.030	21.725	0.000*
Facility -> solid medical waste management	0.641	0.643	0.054	11.832	0.000*
Behavior -> solid medical waste management	0.284	0.283	0.057	4.954	0.000*
Processing type -> solid medical waste management	- 0.343	- 0.340	0.039	8.828	0.000*

Note: *Significant 5% confidence level.

The behavior of human resources has an effect on the management of solid medical waste with a t-statistic value of 4.954 > 1.96. It shows that behavior such as knowledge, attitudes, and good actions about solid medical waste affect the management in reducing, storing, collecting, processing, and transporting waste. The type of treatment affects the management of solid medical waste with a t-statistic value of 8.828 > 1.96, which shows a lower environmental impact and costs. Furthermore, the policy has a value of 0.563 < 1.96, which does not affect the type of solid medical waste treatment.

Based on Table **3**, the R-square value of 0.704 or 70.4% shows that the model formed by the independent variable is very strong in forming the dependent. This indicates that policies, processing methods, facilities, and human resource behavior have a substantial impact on the management of solid medical waste, with only 29.6% of the variance explained by unevaluated variables. Based on the 5% confidence level, there are 29.6% of other factors outside the factors studied that affect good waste management. Predicted other factors in question are cost, awareness of all elements in health services, and others.

Table 3. R-square value.

Variable	R-square
Solid medical waste management	0.704

4. DISCUSSION

The research resulted in waste management steps starting from the waste source, collection, and processing to the disposal process. The first step is to establish policies: the regulations, develop Standard Operating Procedures (SOPs) and work instructions. The second step is providing standard facilities such as containers for infectious and non-infectious solid waste, personal protective equipment, cleaning temporary landfills, and preparing closed means of transportation. The third step is to increase human resources through training to increase knowledge of good attitudes and behavior. The fourth step defines the appropriate sewage treatment method using autoclave, chemical disinfection, and incineration.

Standard-compliant management provides benefits in terms of cost, ease of management, and prevention of dangerous infections in health workers and waste management workers. Cross-contamination can be prevented by properly separating toxic and non-toxic waste, as well as special handling for pathological waste management [16]. According to standards, the right medical waste management strategy does not increase the transmission of COVID-19 in Indonesia [17]. Establishing national waste management policies and plans through a participatory approach is beneficial for reducing social and environmental impacts [18].

Policies such as regulatory documents, SOPs, and work instructions set by hospitals change the behavior of human resources in managing waste. The results are appropriate to Chilshom (2021) that policies regarding managing health facilities such as hospitals, from storage to improper transportation, lead to a medical waste increase. Even some countries such as Ethiopia, Botswana, Nigeria, and Algeria do not have national guidelines for waste management hence

burning is used as alternative disposal [19]. Facilities impact solid medical waste management, consistent with prior research indicating that they can contribute to environmental preservation and realize a "green hospital" [20]. Therefore, health services such as hospitals need to prepare waste treatment facilities to participate in preserving the environment and realizing a green hospital.

Hospital waste is increasing due to low solid medical recycling activities. This is consistent with an earlier study in Malaysia about the cost-effectiveness of waste management through recycling. The waste segregation program reduces costs by 61,000 USD/year [21]. On the other hand, non-standard medical management for waste can result in accidents among officers and nurses. Research in Italy showed that this management could lead to accidents such as being punctured by a needle and sharp objects [22]. The limitations of the study were 3 hospitals in one district and not all hospitals in the district, which allowed for bias. Efforts were made to avoid bias by choosing hospitals with the same strata.

4.1. Solid Medical Waste Management Strategy

This research develops a solid medical waste management strategy based on policies, facilities, the behavior of human resources, and the type of solid medical waste treatment. Research by Maaroufi K. *et al*. [14] explained that these strategies are affected by 5 variables, including operational procedures, facilities, level of trust, awareness, and training. The results are supported by research of Ali [15], which stated that it is necessary to officially enforce regulations related to waste management and conduct training for all hospital personnel. Awareness of disposal regulations is a critical success factor in this management. The results of Maaroufi *et al*. [14] and Ali *et al*. [15] are also supported by Fajar [23], that it is necessary to set a standard operating policy for hazardous waste management procedures, especially in recycling waste.

Maaroufi *et al*. [14], Fajar *et al*. [23] and Ali *et al*. [15] analyzed some of the factors that affect waste management with a quantitative approach. However, the results are straightforward, only concluding the affecting factors in the form of recommendations for improving solid medical waste management and do not develop strategies. Proper management is an effective solution to avoid the impact of waste on the community and financial loss as well as preserve the environment starting from waste separation, collection, transportation, processing, and disposal [24].

A strategy can be implemented in hospitals by setting a priority scale to prepare a complete policy such as regulatory documents, work instructions, or SOPs, starting from reduction and sorting, storage, transportation, processing, burial, and landfilling. The SOP should apply to all officers responsible for waste management. For This reason, in making SOPs, all officers responsible for waste management must be involved. Therefore, they should participate in developing SOP management policies by sorting waste to reduce the amount in landfills [22]. Furthermore, planning was reported as the primary strategy for managing waste [25], and segregation is another important stage [1].

The second priority is the availability of solid medical waste management facilities in the form of an appropriate place or container with its amount, type, and characteristics. It also needs complete personal protective equipment such as helmets, masks, eye protection, aprons, shoes, and gloves, closed waste transportation means, B3 waste final disposal sites equipped with cool storage, and different transportation routes for patients, visitors, and staff. Hospitals should have equipment such as incinerators that can destroy waste independently. The authority and policy to determine the management of health facility waste is the responsibility of the regional government [26].

The third priority is to increase the competence of all human resources in hospitals through solid medical waste management training. Behavior is the responsibility of the individual independently. Encouragement to behave because of good understanding, appropriate information, and effective communication [27, 28]. This is in line with the previous research, which explained that the workers' knowledge, attitudes, and actions are positively correlated with good medical waste management practices [28]. The results showed that the practice of grouping and sorting waste had the highest score, followed by a high score on respondents' knowledge of color coding in classifying solid medical waste. This implies that high understanding is followed by good application [29 - 31].

Appropriate waste management begins with policies at the hospital level. This is in accordance with the results of research conducted and previous research. The results of this study contribute to the management of solid medical waste in hospitals, not only at the research site considered in this study but can also be applied to other hospitals nationally in Indonesia.

CONCLUSION

In principle, the stages of solid medical waste management in hospitals start from reducing and sorting, storing, transporting, processing, burial, and stockpiling. They must be written in the policies that apply to the hospital. The availability of medical waste management facilities is influenced by the presence of containers or places for solid medical waste, Personal Protective Equipment, cleaning materials or disinfectants, Temporary Shelter for Hazardous and Toxic Materials (B3) waste and solid medical waste transportation equipment that supports good medical waste management. Without policy and established Standard Operating Procedures (SOPs), waste management procedures do not have clear rules. Since solid medical waste is a hazardous and toxic material; hospital leaders must establish a solid medical waste management policy. Standard operating procedures (SOPs) must be a guideline that must be carried out by all waste management officers, compiled based on the standard regulation of the Minister of Health of the Republic of Indonesia number 18 of 2020.

Knowledge, attitudes, and actions affect the behavior of human resources in hospital waste management. Furthermore, good and standardized waste management starts from the behavior of human resources in reducing and sorting, storing, collecting, transporting, and processing appropriately with the Indonesia Ministry of Health and the Ministry of Environment

regulations.

Availability of facilities and methods for managing solid medical waste, starting from a place or container for solid medical waste according to the amount, type and characteristics of solid medical waste, complete personal protective equipment (*e.g*., helmets, masks, eye protection, aprons/aprons, e gaiters/shoes and gloves), covered waste transportation equipment. Disposal Sites While B3 waste is equipped with cool storage, the transportation route for transporting waste is different from the route used by patients; visitors support the success of waste management according to standards.

The management strategy is prepared by implementing related regulations and providing facilities, good human resource behavior, and waste treatment to reduce the impact on the environment and costs. Additionally, regular training is important to increase understanding of all human resources, including doctors, nurses, cleaning services, and waste treatment officers, to correctly conduct solid medical waste management. The importance of increasing understanding of solid medical waste management of all human resources, including those responsible for hospitals, doctors, nurses, cleaning services, and waste processing officers through regular waste management training so that solid medical waste management can be carried out properly.

LIST OF ABBREVIATIONS

HTM = Hazardous and Toxic Materials

SEM-PLS = Structural Equation Medelling (modeling?)-Partial Least Square

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

Ethics approval was obtained from The Health Research Ethics Committee at the College Of Health Science "MALUKU HUSADA" (RK.32/KEPK/STIK/VI/2021).

HUMAN AND ANIMAL RIGHTS

No animals were used for studies that are the basis of this research. All the humans were used in accordance with the ethical standards of the committee responsible for human experimentation (institutional and national), and with the Helsinki Declaration of 1975, as revised in 2013 (http://ethics.iit.edu/ecodes/node/3931).

CONSENT FOR PUBLICATION

The written informed consent form was taken from the participants.

STANDARDS OF REPORTING

STROBE guidelines were followed.

AVAILABILITY OF DATA AND MATERIALS

The data sets used and/or analysed during this study are available from the corresponding author upon request.

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CONFLICT OF INTEREST

The authors declare no conflict of interest, financial or otherwise.

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REFERENCES

[1] Arisma N. Gambaran Pengelolaan Limbah Medis Padat Di Rumah Sakit Hi Muhammad Yusuf Kalibalangan Kotabumi Tahun 2019. Jurnal Kesehatan Lingkungan 2021; 15(2): 85. [http://dx.doi.org/10.26630/rj.v15i2.2808]

[2] WHO. Health Care Waste. Genewa. 2018. Available from: https://www.who.int/news-room/fact-sheets/detail/health-care-waste

[3] Kemenkes. Pengelolaan Limbah Medis di Indonesia belum Maksimal. Jakarta, Indonesia: Kementerian Kesehatan Republik Indonesia. 2019. Available from: https://www.ugm.ac.id/id/berita/18264-pengelolaan-limbah-medis-di-indonesia-belum-maksimal

[4] Susi WA, Enri D, Chaerul M. Solid waste generation from healthcare facilities in Surabaya City Indonesia. E3S Web Conf 2020; 148: 2019-1.

[5] Ferronato N, Torretta V. Waste mismanagement in developing countries: A review of global issues. Int J Environ Res Public Health 2019; 16(6): 1060. [http://dx.doi.org/10.3390/ijerph16061060] [PMID: 30909625]

[6] WHO, Unicef. Air, Sanitasi dan Pengelolaan limbah yang Tepat Dalam Penanganan Wabah COVID-19. Pedoman Sementara WHO dan UNICEF 19 Maret. 2020. Available from: https://www.who.int/docs/default-source/searo/indonesia/covid19/who-unicef---air-sanitasi-higiene-dan-pengelolaan-limbah-yang-tepat-dalam-penanganan-wabah-covid-19.pdf?sfvrsn=bf12a730_2

[7] Kemenkes. Pengelolaan Limbah Medis oleh RS sudah sesuai Standar. Jakarta, Indonesia: Kementerian Kesehatan Republik Indonesia. 2020. Available from: www.kemkes.go.id/article/view/20011700005/pengelolaan-limbah-medis-oleh-rs-sudah-sesuai-standar.html

[8] Masruddin M, Yulianto B, Mulasari SA, Sari SI. Pengelolaan Limbah B3 Fasilitas Pelayanan Kesehatan (Medis Padat) Di Puskesmas X. J Kesehat Masy 2021; 5(1): 378-86.

[9] Pourebrahimi S. Upcycling face mask wastes generated during COVID-19 into value-added engineering materials: A review. Sci Total Environ 2022; 851(Pt 2): 158396. [http://dx.doi.org/10.1016/j.scitotenv.2022.158396] [PMID: 36055514]

[10] Ranjbari M, Shams Esfandabadi Z, Shevchenko T, *et al*. Mapping healthcare waste management research: Past evolution, current challenges, and future perspectives towards a circular economy transition. J Hazard Mater 2022; 422(July): 126724. [http://dx.doi.org/10.1016/j.jhazmat.2021.126724] [PMID: 34399217]

[11] Kanagamani K, Geethamani O, Narmatha M. Hazardous waste management. Intechopen 2012; 13.

[12] Hayleeyesus SF, Cherinete W. Healthcare waste generation and management in public healthcare facilities in Adama, Ethiopia. J Health Pollut 2016; 6(10): 64-73. [http://dx.doi.org/10.5696/2156-9614-6-10.64] [PMID: 30524786]

[13] Okeke O. Esperimental and numerical investigation of fire behaviour in polyurethane foams. University of Saskatchewan Saskatoon. 2019. Available from: http://www.diva-portal.se/smash/get/diva2:432427/FULLTEXT01.pdf

[14] Maaroufi K, Tudor T, Vaccari M, Siala A, Mahmoudi E. An evaluation of staff engagement with infectious healthcare waste management policies: A case study of Tunisia. Int J Environ Res Public Health 2020; 17(5): 1704. [http://dx.doi.org/10.3390/ijerph17051704] [PMID: 32150949]

[15] Ali M, Wang W, Chaudhry N, Geng Y. Hospital waste management in developing countries: A mini review. Waste Manag Res 2017; 35(6): 581-92.

[http://dx.doi.org/10.1177/0734242X17691344] [PMID: 28566033]

[16] Geetha S, Narayanamoorthy S, Kang D, Kureethara JV. A novel assessment of healthcare waste disposal methods: Intuitionistic hesitant fuzzy multimoora decision making approach.IEEE Access 2019; 130283-99.
[http://dx.doi.org/10.1109/ACCESS.2019.2940540]

[17] Awali GS, Rahma SA. Strategic during COVID-19 pandemic in a sustainable national waste management program - European Experience in Serbia. J Kesmas Indones 2022; 1-11.

[18] Josimović B, Manić B, Krunić N. Strategic environmental assessment as a support in a sustainable National Waste Management Program—European Experience in Serbia. Energies 2022; 15(13): 4568.
[http://dx.doi.org/10.3390/en15134568]

[19] Chisholm JM, Zamani R, Negm AM, *et al.* Sustainable waste management of medical waste in African developing countries: A narrative review. Waste Manag Res 2021; 39(9): 1149-63.
[http://dx.doi.org/10.1177/0734242X211029175] [PMID: 34218734]

[20] Herman P. Analysis of solid medical waste management to realize. Din Lingkung Indones 2020; 7(1): 43-52.
[http://dx.doi.org/10.31258/dli.7.1.p.43-52]

[21] Rangga JU, Syed Ismail SN, Rasdi I, Karuppiah K. Waste management costs reduction and the recycling profit estimation from the segregation programme in Malaysia. Pertanika J Sci Technol 2022; 30(2): 1457-78.
[http://dx.doi.org/10.47836/pjst.30.2.34]

[22] Ferrante M, D'Agati P, La Rosa SDM, Carini SA, Trovato A, Fiore M. Stinging-cutting accidents and healthcare waste management's knowledge among healthcare professionals in public hospitals in Catania (South Italy). Open Public Health J 2018; 11(1): 330-8.
[http://dx.doi.org/10.2174/1874944501811010330]

[23] Fajar MI, Nadiroh N, Muzani M. Solid waste management policy not derived from hazardous and toxic materials through re-use or re-cycling for environmental preservation. J Green Growth Environ Manag 2018; 7(2): 148-59.

[24] Shwetmala K, Arkalgud R, Anilkumar M. A roadmap for bio-medical waste management research. Int J Health Plann Manage 2021; 36(4): 1251-9.
[http://dx.doi.org/10.1002/hpm.3170] [PMID: 33855739]

[25] Saarani PSN, Abdul Tharim AH, Che Ahmad A, Mohamed Salleh R. A Systematic Literature Review (SLR) on the strategies of managing waste in relative to Green Building (GB) practice. Pertanika J Sci Technol 2022; 30(2): 1363-80.
[http://dx.doi.org/10.47836/pjst.30.2.28]

[26] Sitompul PPE. Observing the B3 waste treatment policy in health care facilities during the COVID-19 pandemic in West Java Province. Dinamika Lingkungan Indonesia 2021; 8(1): 73.
[http://dx.doi.org/10.31258/dli.8.1.p.73-79]

[27] Utami TN, Usiono U, Sayekti R. Analyzing the adoption of clean and healthy living behaviors against COVID-19 students in Indonesia. Open Public Health J 2022; 15(1): e187494452208290.
[http://dx.doi.org/10.2174/18749445-v15-e2208290]

[28] Kaur R, Kant S, Lohiya A, Ahamed F, Malhotra S, Haldar P. Access and utilization of sanitation facilities in a Rural Area of Haryana, North India. Indian J Public Health 2020; 64(4): 357-61.
[http://dx.doi.org/10.4103/ijph.IJPH_416_19] [PMID: 33318385]

[29] Akkajit P, Romin H, Assawadithalerd M. Assessment of knowledge, attitude, and practice in respect of medical waste management among healthcare workers in clinics. J Environ Public Health 2020; 2020: 8745472.

[30] Hassan MM, Ahmed SA, Rahman KA, Biswas TK. Pattern of medical waste management: Existing scenario in Dhaka City, Bangladesh. BMC Public Health 2008; 8(1): 36.
[http://dx.doi.org/10.1186/1471-2458-8-36] [PMID: 18221548]

[31] Nordahl SL, Devkota JP, Amirebrahimi J, *et al.* Life-cycle greenhouse gas emissions and human health trade-offs of organic waste management strategies. Environ Sci Technol 2020; 54(15): 9200-9.
[http://dx.doi.org/10.1021/acs.est.0c00364] [PMID: 32628836]