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MEDICAL WASTE MANAGEMENT IN PRIVATE CLINICS IN SURABAYA AND FACTORS AFFECTING IT

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ABSTRACT: Health care services generate solid wastes that impose environmental risk if not properly managed, especially the one categorized as hazardous. The compliance of those facilities to the regulation regarding waste management—from the source by waste reduction, segregation, storage, transportation, treatment, and burial— is important to be investigated to identified whether it has been conducted properly. This study was conducted in 17 representative clinics by sampling their solid waste for five consecutive days, observing whether the operation of their solid waste management is conforming the related regulations, and performing logistic regression analysis to develop the correlation between independent variables (sanitary officer that specifically responsible for managing waste; routine budget allocated for waste management; standard operational procedure (SOP) for waste management; and waste management training for staffs) and dependent variables (color-coded waste containment; symbol assignment on waste container; and waste storage location). The results show that the medical waste generation rate was 0.070 kg/patient/day. Composition of the waste from clinics comprised of 21% sharps, 42% infectious, and 37% general waste. The process of solid waste segregation, collection, and storage has not complied with the standard regulated by the government. Logistic regression analysis shows that for implementation of color-coded container the affecting factors are budget and SOP; for the availability of waste storage is staff training; while for symbol assignment there seem to be no significant factors affecting it.

Keywords: Binary logistics regression, Health care clinics, Medical waste, Solid waste management, Surabaya City

1. INTRODUCTION

Healthcare solid waste is waste generated from activities in healthcare facilities such as hospitals, clinics, research centres, and laboratories related to medical procedures. Of this waste, 75–95% consists of non-hazardous, domestic-like waste that poses no health or environmental risks, and 10–25% is composed of hazardous waste that poses health and environmental risks [1]. Due to its infectious nature, this waste must be well managed to prevent it from spreading diseases [2],[3]. Infectious diseases such as cholera, dysentery, skin infections and hepatitis can be epidemically spread by improper medical solid waste management [4]. Inadequate waste treatment and disposal can also cause indirect health risks. Waste landfill, when not properly managed, may release pathogens, toxic pollutants, and odours to the environment. It can also expedite the growth of insects, rodents, and worms that lead to the spread of diseases. Improperly operated waste incineration may emit dangerous gases to the environment [1]

The difficulties faced by developing countries in managing their medical solid waste is caused by a lack of financial investment, awareness on the part of administrators, trained staff, and appropriate technologies. Furthermore, the absence of national-level standards and regulations leads to ineffective control and an inability to impose legal penalties on those who neglect their waste management duties [5]. Several developing countries, including Jordan, Iran, Brazil, India, Cameroon, Botswana, Vietnam, and Nepal, to name a few, have already implemented ministerial-level medical waste management regulations [6]. Indonesia also has comparable regulations. Environment and Forestry Ministry Regulation number 56, regulate the management of hazardous waste from health care facilities. This regulation has been adopted by Ministry of Health to regulate and monitor clinics by issuing Ministry of Health Regulation no 27 2017, Guidelines for Infection Prevention and Control at Health Service Facilities. This regulation standardises the management of hazardous waste at the point of origin by regulating waste reduction, segregation, containment, transportation outside the facility of origin, treatment and burial [7].

Unfortunately, many healthcare facilities fail to comply with these regulations, continuing to improperly dispose of their waste without punishment [8]. These facilities dispose of their untreated medical waste mixed with general waste in open areas [9]. The limited availability of waste collection facilities, including the use of unsafe containers and the absence of colour-coding for medical waste, also posed obstacles to proper waste segregation [8]. The segregation of waste in accordance with its type, waste containment, as well as storage that complies with standards, is key to the control of risk at the origin of waste. The owners or operators of healthcare clinics play a crucial role in this process. Segregation is the key to minimizing waste. It can reduced the amount of medical waste to be treated up to 70.1% thus reduce significant amount of cost [10]. Mistakes in segregating waste at the source or placing the waste in the wrong container occurred in small hospitals and clinics [11]. The well-executed waste segregation at the source by providing good containers is the early steps of a good waste management that are important to do.

Logistic regression model is one of regression methods used to find out the correlation of categorized response variable with one or more independent variable as category or continue. The research objectives were to investigate the management of medical solid waste in clinics in Surabaya, and to determine the factors that influence the implementation of waste containment and storage using logistics regression.

2. METHODS

This research is a descriptive study of solid waste management in clinics in Surabaya City that took place in 2017. Out of 285 clinics, the study was conducted in 17 clinics, spread across the city, that were willing to issue a formal permit. Waste generation sampling was performed over five consecutive working days by weighing the waste and recording the number of outpatients. To investigate the clinics' compliance with the waste management regulations set out in Ministry of Environment and Forestry Regulation No. 56, 2015, observation and survey questionnaires were also conducted.

The clinics' waste management practices were analysed using binary logistics regression. Four independent variables were determined for this analysis: a sanitary officer specifically responsible for managing waste (X_1), routine budget allocated for waste management (X_2), standard operating procedure (SOP) for waste management displayed in the clinic (X_3), and waste management training for staff (X4). The dependent variables being observed were: colour-coded waste containment (Y_1), symbol assignment on waste containers (Y_2), and waste storage location (Y_3). The absence of any of these variables was coded '0' and its presence was coded '1' [12]. The complete set of variables used for the logistic regression model is presented in Table 1.

Table 1 Variables used for logistic regression model

No	Variable	Coding
	Independent	
1	Sanitary officer (X_1)	1 = Present 0 = Absent
2	Waste management routine budget (X_2)	1 = Present 0 = Absent
3	Waste management SOP (X_3)	1 = Present 0 = Absent
4	Waste management training (X_4)	1 = Present 0 = Absent
	Dependent	
1	Colour-coded container (Y_1)	1 = Present 0 = Absent
2	Symbol assignment on container (Y_2)	1 = Present 0 = Absent
3	Waste storage location (Y_3)	1 = Present 0 = Absent

Modelling analysis was conducted using IBM SPSS 20 software. Three models resulted: colour-coded container model, symbol assignment model, and waste storage model. The logistic regression model follows Eq. (1).

$$p(Y) = \frac{\exp(\beta_0 + \beta_1 x_1 + \ldots + \beta_k x_k)}{1 + \exp(\beta_0 + \beta_1 x_1 + \ldots + \beta_k x_k)} \tag{1}$$

where β_0 is constant, β_j is the regression coefficient and j is the number of predictor (independent) variables.

The logistic regression model requires predictor variables to have no multicollinearity. By calculating VIF, the multicollinearity can be determined. If VIF is less than 10 or the tolerance is more than 0.1, then the variables are free of multicollinearity. Table 2 presents the results of the multicollinearity test, which shows that the dependent variables used in this study fit the requirement.

Table 2 Multicollinearity test

Variables	Tolerance	VIF
Sanitary officer (X_1)	0.362	2.765
Waste management routine budget (X_2)	0.881	1.135
Waste management SOP (X_3)	0.283	3.532
Waste management training (X_4)	0.178	5.603

3. RESULT AND DISCUSSION

Surabaya City is the capital city of East Java Province, a metropolis with 2,95 million inhabitants covering an area of 33.306 Ha. Healthcare facilities in the city comprise 61 hospitals offering various classes and types of services, 63 community health centres, and 285 clinics [13].

The clinics observed in this study are privately owned. The establishment of a clinic is subject to government permission and the clinic owner must obtain an operational permit. Subsequently, the government will guide and supervise its operation. Clinics must comply with regulatory requirements governing their location, buildings, rooms, infrastructure, equipment and staffing. One of these requirements is to have waste management facilities [14].

3.1 Waste Management in Clinics

All clinics studied already separate their medical and non-medical (domestic-like) waste. Medical waste is further separated into sharps and infectious waste, which are contained in different containers. Government-owned community health centres in Surabaya separate their waste in a similar manner.

According to the regulations, medical waste containers must be equipped with lids or covers made of a puncture- and leak-resistant material. They must be lined with yellow plastic bags and must feature a proper identifying symbol according to the nature of the waste they contain. The survey results show that the containers in use are equipped with hard plastic lids, but only 41.2% of clinics use yellow containers, and only 29.4% of clinics have affixed infectious symbols on containers. The sharps symbol has been used because sharps are contained in special containers made of thick cardboard. Fig. 1 shows the typical containers used to contain medical waste in clinics.

Fig. 1 Containment of medical waste, sharps and non-medical waste

The five-day waste generation sampling shows that the waste generated by clinics consisted of 21% sharps, 42% infectious waste, and 37% general waste. This composition differs from the composition of hospital solid waste in other developing countries. In Tripoli, Libya, the composition of sharps, infectious waste and general waste is 4%, 21%, and 74%, respectively. In Dhaka, Bangladesh, the composition is 2.8%, 18.4% and 78.7%, respectively, while in Gujranwala, Pakistan, the composition is 0.87%, 25.8% and 73.8%, respectively [6]. This discrepancy arises because clinics only provide outpatient services; as a result, the waste generation from patients and staff activities are limited.

The waste generation survey results show the generation of 0.07 kg/patient/day of medical waste and 0.040 kg/patient/day of non-medical waste. The patients visiting clinics are solely to get treatment and no other activities, therefore the genaration of non medical waste is low. The rate at which clinics in this study generated medical waste is similar to the rates in Pakistan (0.06 kg/patient/day), South Africa (0.07 kg/patient/day) and Tanzania (0.01 kg/patient/day) [1]. Surabaya City Health Department recorded 256,143 patients per day, giving a waste generation figure of approximately 18 tonnes/year—a sizeable number that must be given serious attention.

Non-medical waste does not require special treatment; thus, it is directly transferred to the nearest temporary waste storage site to await transportation to the government-owned landfill in Benowo. In contrast, medical waste requires special treatment. None of the clinics studied treat their own waste. They must therefore subcontract this activity to another party who has permission to transport and treat hazardous waste. Unfortunately, not all clinics were able to produce a manifest to prove that their subcontractors had the proper permits. The small volume of waste generated by the clinics means that daily transportation by the third party is impractical. Therefore, clinics must provide a waste storage area. This area must be protected with an impermeable floor and must be free of rodents and other animals. The maximum storage time is two days; if storage exceeds this timeframe, the waste must be kept at or below 0° Celsius. The survey shows that only 41.2% of clinics provide a special safe room, without a cooler, for storing their medical waste. The rest of the clinics keep their medical waste in a standard storage area or other unspecified space within the clinic, without posting any signs.

The success of solid waste management depends on the organisational capabilities of the clinic's management, such as the presence of operations staff, operational guidance and adequate budget, as well as the clinic's staff's knowledge regarding how to properly manage the waste. The survey shows that only 11.8% of clinics have a dedicated sanitary manager, while the rest allocate responsibility for waste management to administrative staff. Only 47.1% of clinics allocate a routine budget for waste management. Moreover, only 23.5% of clinics have standard operating procedures for waste management, while a mere 17.6% of clinics have staff that have been trained in waste management. These low numbers show the lack of awareness of clinic management of the importance of medical waste management. On the other hand, the absence of routine government control mechanisms to enforce clinics' compliance with regulations worsens the situation. For better medical waste management, Surabaya Government needs to make an effort to increase awareness, provide readily applied guidance or SOPs, and—if needed—stimulant funding for clinics to manage their medical waste. Provision of a good waste management facility as an example for clinics may also be useful.

The correlation between the presence of dedicated sanitary staff, operational procedures, budget and training, on the one hand, and colour-coded containment, symbol assignment and storage area provision, on the other, is analysed using logistic regression.

3.2 Logistic Regression Model for Colour-Coded Waste Container

The first step in creating a logistic regression model is to perform a univariate test model between the dependent variables with each independent variable. The test on β_j will show whether a predictor variable can feasibly fit into the model. Each feasible variable will be modelled for the colour-coded container. The hypothesis is as follows:

H_0: $\beta_j = 0$ (no partial effect)
H_1: $\beta_j \neq 0$, (has partial effect)
where j = 1, 2, 3, 4

Table 3 Univariate logistic regression test on colour-coded container

Independent Variable	B	Wald	Sig.
Var Dep.: colour-coded container (present vs absent)			
Sanitarian (X_1)	21.89	0.00	0.99
Routine Budget (X_2)	1.76	2.64	0.10*
SOP (X_3)	1.91	2.15	0.14*
Training (X_4)	1.28	0.91	0.34

Note: $\alpha = 15\%$

Based on Table 3, when $\alpha = 15\%$, the independent variables routine budget and SOP significantly affect the implementation of a colour-coded container for medical waste, showed by a sig. value of less than $\alpha = 15\%$; therefore, H_0 is rejected. A value of $\alpha = 15\%$ was applied because of this study's small sample size (n = 17), giving a very small error tolerance. Subsequently, a parameter significance test was performed with the multivariate model, as shown in Table 4.

Table 4 Multivariate logistic regression test on colour-coded container

Independent Variable	B	Wald	Sig.
Var Dep.: colour coded container (vs absent)			
Constant	-1.99	3.36	0.07*
Routine Budget (X_2)	2.10	2.64	0.10*
SOP (X_3)	2.32	2.15	0.14*

Note: $\alpha = 15\%$; $R^2 = 0.387$

Based on Table 4, it can be concluded that budget and SOP significantly affect the implementation of colour-coded containers, as shown by sig. being smaller than $\alpha = 15\%$, which means that H_0 is rejected. The resulting simultant logistic model is expressed as Eq. (2):

$$g(x) = -1{,}99 + 2{,}10\,\text{Routine\_budget}_{(1)} + 2{,}32\,\text{SOP}_{(1)} + e \quad (2)$$

with a probability function fit expressed by Eq. (3):

$$\pi(x) = \frac{\exp(-1.99 + 2.10\,\text{Routine\_Budget}(1) + 2.32\,\text{SOP}_{(1)})}{1 + \exp(-1.99 + 2.10\,\text{Routine\_Budget}(1) + 2.32\,\text{SOP}_{(1)})} \quad (3)$$

3.3 Logistic Regression Model for Symbol Assignment On the Waste Container

Table 5 shows that the independent variables with a sig. of less than $\alpha = 15\%$ are budget and SOP, which means that both variables significantly affect symbol assignment. Subsequent multivariate analysis, as shown in Table 6, demonstrates that those variables did not simultaneously affect the implementation of symbol assignment on the waste container, as indicated by the sig. value exceeding $\alpha = 15\%$.

Table 5 Univariate logistic regression test on symbol assignment on waste container

Independent Variable	B	Wald	Sig.
Var Dep.: symbol assignment (vs absent)			
Sanitarian (X_1)	1.01	0.44	0.51
Routine Budget (X_2)	2.08	2.66	0.10*
SOP (X_3)	2.80	4.08	0.04*
Training (X_4)	1.99	2.06	0.15

Note: $\alpha = 15\%$

Therefore, for this model, only a univariate model results; we were unable to produce simultaneous probability using a multivariate model.

Table 6 Multivariate logistic regression test on symbol assignment on waste container

Independent Variable	B	Wald	Sig.
Var Dep.: symbol assignment (vs absent)			
Routine Budget (X_2)	-0.29	0.15	0.70
SOP (X_3)	1.25	1.04	0.31

Note: α = 15%; R^2 = 0.642

3.4 Logistic Regression Model for Waste Storage Area

The third model generated is a logistic regression with waste storage area as the dependent variable. Table 7 shows that the independent variables with a sig. of less than α = 15% are SOP and training. This means that both of these variables significantly affect whether clinics provide storage for their medical waste or not.

Table 7 Univariate logistic regression test on waste storage area

Independent Variable	B	Wald	Sig.
Var Dep.: storage area (vs absent)			
Sanitarian (X_1)	-0.69	1.60	0.21
Routine Budget (X_2)	-0.69	0.96	0.33
SOP (X_3)	-1.20	3.34	0.07*
Training (X_4)	-0.92	2.39	0.12*

Note: α = 15%

The subsequent multivariate logistic regression test (Table 8) on independent variables found to have an effect in the univariate modelling (X_3 and X_4) resulted in the emergence of one significant independent variable: training. The sig. of variable X_4 which is staff training, is less than α = 15%; thus, H_0 is rejected. Therefore, the only variable that has a significant effect on the clinic's provision of a waste storage area is whether or not any training is provided for their staff. The resulting model is expressed as Eq. (4):

$$g(x) = -1{,}204\,\text{Training}_{(1)} + e \quad (4)$$

with the probability function expressed as Eq. (5):

$$\pi(x) = \frac{\exp(-1{,}204\,\text{Training}_{(1)})}{1+\exp(-1{,}204\,\text{Training}_{(1)})} \quad (5)$$

Table 8 Multivariate logistic regression test on waste storage area

Independent Variable	B	Wald	Sig.
Var Dep.: storage area (vs absent)			
SOP (X_3)	21.61	0.00	0.99
Training (X_4)	-1.20	3.34	0.07*

Note: α = 15%; R^2 = 0.642

The R^2 of the model was 57.2% indicating that two independent variables, SOP and trianing, can partially explain Y3 variable which is medical waste storage. While the remaining 42.8% is described by other variables outside the model.

Based on the probability function developed, clinics that arrange medical waste training (X4 = 1) has the probability to provide medical waste storage of 0.230.

4. CONCLUSION

This study successfully obtained data on the generation and composition of solid waste from clinics in Surabaya. Composition of waste fromm clinics comprised of 21% sharps, 42% infectious, and 37% general waste. Waste generation survey results show that medical waste generation was 0.070 kg/patient/day, and non-medical was 0.040 kg/patient/day.

The segregation of solid waste into non-hazardous and hazardous categories is being undertaken by all clinics. Nevertheless, waste containment is not compliant with the regulations governing the proper management of hazardous medical waste. Clinics subcontract the treatment of their medical waste to third parties; therefore, they require temporary storage for their waste prior to its transportation to treatment facilities. Not all clinics have an appropriate storage area. Moreover, not all clinic operators have special sanitary staff, routine budgets, SOPs, and training for their staff.

The performance of a logistic regression analysis demonstrated that the factors that significantly affect the implementation of colour-coded waste containers in clinics are the presence of a routine budget and SOPs for medical waste management. A multivariate logistic analysis modelling the assignment of the symbol on waste containers yielded no significant variable. Thus, the model is based only on a univariate analysis. As for appropriate waste storage areas, the most significant factor affecting their presence is the waste management training provided to the clinic's staff.

This results show that assistance and supervision to clinics by Ministry of Health as the one who issue the operational permit must be improved. This is to ensure that the solid waste generated does not harm environment and health. Future research need to be conducted to further study the routine budget provided by clinics, as well as how good the staffs in charge knowledge of medical waste management.

REFERENCES

[1] Chartier, Y., Emmanuel, J., Pieper, U., Rushbrook, P., Stringer, R., Townend, W., Wilburn, S., Zghondi, R., Safe management of wastes from health-care activities, World Health Organization, 2014, pp. 3-21.

[2] El-Salam, M.M. A, Hospital waste management in El-Beheira Governorate, Egypt, Journal Environmental Management, Volume 91, Issue 3, 2010, pp. 618–629.

[3] Al-Khatib, I.A., Sato, C., Solid health care waste management status at health care centers in the West Bank-Palestinian Territory, Waste Management, Volume 29, Issue 8, 2009, pp. 2398–403.

[4] Coker, A., Sangodoyin, A., Sridhar, M., Booth, C., Olomolaiye, P., Hammond, F., Medical waste management in Ibadan, Nigeria: obstacles and prospects, Waste Management, Volume 29, Issue 2, 2009, pp. 804–11.

[5] Liu, H.C., You, J.X., Lu, C., Shan, M.M., Application of interval 2-tuple linguistic MULTIMOORA method for health-care waste treatment technology evaluation and selection, Waste Management, Volume 34, Issue 11, 2014, pp 2355–2364.

[6] Ali, M., Wang, W., Chaudhry. N., Geng, Y., Hospital Waste Management in Developing Countries: A Mini Review, Waste Management Research, Volume 35, Issue 6, 2017, pp.1-12

[7] Ministry of Environment and Forestry Indonesia, No. 56 The Year 2015, Technical Procedures and Requirements Management of Hazardous and Toxic Waste Material from Health Care Service Facilities.

[8] Irianti, S., Heart, S, Prasetyoputra, P., Determinant of Hospital Waste Management in Indonesia: Focusing on the importance of Segregation at Souerce and Color Coded Collection System, Journal of Applied Science in Environmental Sanitation, Volume 8, Issue 2, 2013, pp. 135-144.

[9] Chaerul, M., Tanaka, M., Shekdar, A.V., A system dynamics approach for hospital waste management, Waste Management, Volume 8, Issue 2, 2008, pp. 442–449.

[10] Taghipour, H., Mosaferi, M., 2009. Characterization of medical waste from hospitals in Tabriz, Iran, Science Total Environment, Issue 407, 2009, pp. 1527–1535.

[11] Zhang, H.J., Zhang, Y.H., Wang, Y., Yang, Y.H., Zhang, J., Wang, Y.L., Wang, J.L., 2013. Investigation of medical waste management in Gansu Province, China, Waste Management & Research, Volume 31, Issue 6, 2013, pp. 655–659.

[12] Agresti, A. An Introduction to Categorical Data Analysis, John Wiley and Son, Second Edition, 2007, pp. 99-121.

[13] Wilujeng, S., Damanhuri, E., Distribution Pattern of Solid Health Care Waste in Surabaya, Conference Proceedings, in Proceeding International Seminar on Environmental Health and Sustainable Tourism, Udayana University, Bali Indonesia, 2016, pp.242-254.

[14] Wilujeng, S., Damanhuri, E., Chaerul, M., Management of Solid Waste from Community Health care Facility in Surabaya City, Conference Proceedings, in Proceeding International Conference on Green Agro Industri and Bioeconomy, Universitas Brawijaya, Malang Indonesia, 2017, pp.115-119.