

**WASTE MANAGEMENT IN INDONESIAN PUBLIC HEALTH CENTRES:
FACTORS ASSOCIATED WITH WASTE SEGREGATION PRACTICES AND
DISPOSAL METHODS**

**Pengelolaan Limbah di Pusat Kesehatan Masyarakat Indonesia: Faktor-Faktor
yang Berhubungan dengan Praktik Pemisahan Limbah dan Metode Pembuangan**

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ABSTRAK

Pada tahun 2014 Indonesia mulai menerapkan Universal Health Coverage (UHC), yang akan meningkatkan cakupan asuransi kesehatan. Artinya bahwa pemanfaatan layanan kesehatan akan meningkat juga, sehingga pengelolaan limbah medis di pusat kesehatan masyarakat (puskesmas) akan menjadi semakin penting. Artikel ini merupakan analisis data Riset Fasilitas Kesehatan (Rifaskes) yang dilakukan oleh Badan Litbang Kesehatan tahun 2011 tentang faktor-faktor yang mempengaruhi pemisahan limbah dan pembuangan akhir limbah layanan kesehatan di Puskesmas. Jumlah sampel adalah 8.599 Puskesmas. Variabel yang dianalisis meliputi sistem pembuangan limbah, perilaku pemisahan limbah, dan pengolahan limbah dengan cara dibakar. Analisis data dilakukan secara multivariat dengan model logistik biner multivariabel dan regresi multinomial pada tingkat signifikansi 0,05. Hasil analisis regresi multivariabel menemukan bahwa ada ketidaksetaraan berbasis geografis di mana Puskesmas yang terletak di wilayah Jawa-Bali, di daerah perkotaan, bukan di daerah terpencil, dan di pulau-pulau utama, cenderung melakukan pemisahan limbah medis, dan cenderung tidak melakukan praktik pembakaran terbuka. Puskesmas yang memiliki sistem pembuangan limbah yang layak, mengindikasikan bahwa memiliki kecenderungan mempraktikkan pemisahan limbah medis (tidak pembakaran terbuka). Sebaliknya puskesmas di daerah pedesaan, tidak melakukan pemilahan limbah dan cenderung mengelola sampah dengan cara dibakar. Hal ini mengindikasikan bahwa sumber daya untuk menerapkan pengelolaan limbah layanan kesehatan yang tepat di Puskesmas, termasuk fasilitas dasar, pelaksanaan pemisahan di sumber, dan pengolahan serta pembuangan limbah yang tepat menjadi sangat penting.

Kata kunci: Limbah medis, fasilitas kesehatan, analisis regresi, pengelolaan limbah, Indonesia

ABSTRACT

In 2014, Indonesia started implementing Universal Health Coverage (UHC). As coverage of health insurance expands, healthcare utilisation will increase. Therefore, sustainable healthcare waste management (HCWM) in public health centres (PHCs) will become more important. This paper addresses the drivers of waste segregation and the final disposal of healthcare wastes. We obtained data on health care waste management (HCWM) in 8,599 PHCs from the 2011 Health Facility Research (Rifaskes). We then fitted multivariable binary logistic and multinomial regression models at the 0.05 level of significance. The multivariable regression analyses found that there were geographically based inequalities where PHCs located in JavaBali region, in the urban area, not in the remote area, in main islands, were more likely to practice medical waste segregation, and less likely to practice open burning. Owning a sewerage system corresponds to a higher likelihood of practising medical waste segregation and lower likelihood of open burning. Moreover, PHCs with better basic amenities were more likely to segregate their waste and less likely to practice open burning. This paper recommends the importance of resource for establishing proper HCWM in PHCs including basic amenities, implementation of segregation at source, and appropriate waste treatment and disposal.

Keywords: Medical waste; health facilities; regression analysis; waste management; Indonesia

INTRODUCTION

Indonesia had paid some attention to the importance of safe health care waste management (HCWM) since 1999, when the World Health Organisation (WHO) published a guideline for safe HCWM, to guide developing countries to establish HCWM, according to their capabilities, resources and technologies (Prüss, Giroult, & Rushbrook, 1999). A study on hospital sanitation was conducted by the Indonesian Ministry of Health (MoH), funded by the WHO Country Office for Indonesia, including the assessment of existing hospital waste management (Sasimartoyo, 2004). The results revealed that hospital waste management was far from satisfactory, concerning the availability of relevant regulations, segregation practices, provision of colour-coded plastic bins, temporary storage, and treatment technology (Sasimartoyo, 2004). After more than a decade, there has been little improvement, as many PHCs remained dispose of their medical waste improperly. Moreover, sustainable HCWM practice in PHCs lacks the implementation of proper waste segregation and final disposal as to minimise the adverse impact of medical waste generated.

As of January 2014, Indonesia started implementing Universal Health Coverage (UHC) according to National Social Security System Act No. 40/2004 (Agustina *et al.*, 2018; Government of Indonesia, 2004). As coverage of health insurance expands, healthcare utilisation will increase. As a result, sustainable healthcare waste management (HCWM) in health facilities will become more critical regarding quantity and its potential impact (Chartier *et al.*, 2014). The UHC in Indonesia employs public health centres (PHCs) as one of its primary care providers. The 2011 Health Facility Research reported that one in three PHCs did not practice medical waste segregation, and of those who did, almost half reported burning their medical waste in the open area (NIHRD, 2012). These situations entail potential health risks to healthcare workers and community near the PHCs (Adama, Esena, Fosu-Mensah, & Yirenya-Tawiah, 2016; Oyekale & Oyekale,

2017; Udofia, Gulis, & Fobil, 2017). The exposed population increases as healthcare utilisation increases. More research that explores the determinants of segregation and final disposal of medical wastes is needed to improve HCWM in PHCs. In 2013, Irianti, Prasetyoputra, and Herat (2013) analysed HCWM data from 237 state hospitals in Indonesia. They revealed that variables such as availability of budget, central government policy, hospital management policy, and standard operating procedure in hospital wards were positively associated with medical waste segregation practices.

Previously, the World Bank and the Indonesian National Institute of Health Research and Development (NIHRD) conducted an assessment of the supply-side readiness of health facilities using data from the Health Facility Research (*Riset Fasilitas Kesehatan – Rifaskes*) in 2011 (Kosen *et al.*, 2014; World Bank & NIHRD, 2014). However, their focus was on Non-Communicable Diseases and Maternal Healthcare, and they aggregated the 2011 Rifaskes data to the district level and only considered HCWM as part of basic amenities.

Studies on HCWM in Indonesia are scant, and it applies in particular on a national scale as Indonesian studies often are case studies of several hospitals or PHCs. Dealing with PHCs, there was no national data regarding HCWM before 2011 when Health Facility Research was conducted (NIHRD, 2012). In fact, an assessment was carried out in Yogyakarta by Program for Appropriate Technology in Health (PATH) revealed that majority of PHCs did not manage their wastes properly as there was reuse practice of disposable syringes and poor waste segregation at source (PATH, 2005). Therefore, this paper is aimed at investigating the factors associated with medical waste segregation practices and method of final disposal of medical wastes at the primary care level to guide policymaking in healthcare waste management in Indonesia. The results of this paper can fill the HCWM knowledge gap and inform policy-making in waste management in Indonesia.

The remainder of the paper is as follows. The following section outlines the secondary dataset used and the method of statistical analysis. The section afterwards presents and discusses the main empirical results. The last part then concludes and suggests.

MATERIALS AND METHODS

Data Source

The data source for this paper is the 2011 Rifaskes collected by the NIHRD, Ministry of Health. The 2011 Rifaskes is the first national cross-sectional census of government health facilities (hospitals and PHCs) and laboratories based on the registered number of such facilities in 2010 (NIHRD, 2012). The Rifaskes collects data on the infrastructure, human resource, medical devices, organisation and management, outpatient service, and essential output of health services. At the time of the census, there were 9188 PHCs. However, after data cleaning or listwise deletion process, the final complete sample was 8981 PHCs (97.75%). At the time when this manuscript was written, the 2011 Rifaskes is the most recent census as data collection of the second Rifaskes is being conducted this year and the raw data cannot be accessed yet. Moreover, data equivalent to the Rifaskes that can be used for the analysis in this study does not exist in Indonesia.

Ethics Statement

Ethical clearance for the 2011 Rifaskes was issued by Institutional Review Board of the Indonesian Ministry of Health (No.: KE01.04/EC/193/2011). The NIHRD have made all the PHCs anonymous and created a new ID for each data request. As this paper is a further analysis of the 2011 Rifaskes data, an additional ethical clearance is deemed as unnecessary.

Outcome Variables

There are two outcomes of interest in this paper. The first one is waste segregation in the PHCs. It was administered by asking whether the PHCs segregate medical waste

from general waste (coded as 1 if the response is "Yes" and 0 if otherwise). The second outcome is the method of final disposal of medical wastes. It was administered by further asking the PHCs that answered yes for waste segregation, the method of final disposal of medical wastes. It was coded as 1 if the response is incineration, coded 2 if the response is open burning, coded 3 if the response is buried, and coded 4 if the response is other ways of disposal.

Explanatory Variables

The explanatory variables were selected based on the conceptual framework, public health importance, and statistical significance (Adams, Bartram, & Chartier, 2008). The explanatory variables were categorised into the following categories: basic amenities (access to power, water source and availability, sanitation facility), geographical characteristics (development region, rurality, proximity of residence, remoteness, located on a small island), human resources (number of sanitarians working in the PHCs), management and planning (total of realized budget, retribution collection, organizational structure and work plan availability), and laboratory test services provided.

Statistical Analysis

This study is a cross-sectional analysis of secondary data from the 2011 Rifaskes. There are two outcome variables in this paper. Thus, there are two statistical models, namely Medical Waste Segregation Model and Type of Medical Waste Final Disposal Model. Before the statistical analyses, the listwise deletion was performed to handle the missing values (Dong & Peng, 2013). All of the statistical analyses were conducted using Stata version 13.1 (StataCorp, 2013).

For Model 1, a multivariable binary logistic regression model (LRM) was fitted (Hosmer, Lemeshow, & Sturdivant, 2013). The explanatory variables were further chosen based on statistical significance evaluated at 0.05 level of significance. Odds ratio (OR) and its respective 95 per cent

confidence interval (CI) were used to assess the association between the explanatory variables and waste segregation. The Tjur's Coefficient of Determination was used to evaluate goodness-of-fit of the LRM (Tjur, 2009).

As for Model 2, a multivariable multinomial logit model (MLM) was fitted since the categories of the outcome variable were considered as nominal (Long & Freese, 2014). The explanatory variables were further chosen based on statistical significance evaluated at 0.05 level of significance. Relative-risk ratios (RRR) and its respective 95 per cent CI were also used to assess the association between the explanatory variables and the type of final disposal of medical wastes. This measure of association is commonly used in studies employing MLM. Adjusted McFadden R-squared will be used to evaluate goodness-of-fit of the MLM (McFadden, 1987).

RESULTS

Sample Characteristics

The listwise deletion process led to the omission of 382 PHCs (4.25%) due to missing values leaving 8,599 PHCs for the final analytic sample for the regression analyses. Table 1 presents the baseline characteristics of the analytic sample. It is observed that more than a third (35.02%) of PHCs reported not segregating their medical waste from non-medical waste. As for Model 2, the sample size is reduced to 5,588 PHCs (64.92%) as only the disposal method question was administered to the PHCs that reported segregating their medical wastes. It can be seen that the majority of PHCs reported burning their medical wastes in the open (45.88%) or using incinerators (41.86%). Only 6.66% of PHCs reported dumping their medical waste while 5.60% reported using other methods.

Table 1. Sample characteristics

Variables	Categories	N	(%)
Medical waste is segregated from non-medical waste (DV1)	No (Ref.)	3011	35.02
	Yes	5588	64.92
Disposal method of all medical wastes (DV2)*	Burned in incinerator	2339	41.86
	Burned openly	2564	45.88
	Dumped without burning	372	6.66
	Other	313	5.60
Development region	Java & Bali Islands (Ref.)	3476	40.42
	Sumatra Island	2187	25.43
	Other region	2936	34.14
Location of PHC	Urban area (Ref.)	2231	25.94
	Rural area	6368	74.06
Remoteness of PHC	Not remote (Ref.)	6351	73.86
	Remote	1453	16.90
	Very remote	795	9.25
PHC located on a small island	No (Ref.)	8050	93.62
	Yes	549	6.38
Year-long availability of water	No (Ref.)	1402	16.30
	Yes	7197	83.70
Main water source	Piped connection (Ref.)	2875	33.43
	Bored well	2086	24.26
	Dug well	2342	27.24
	Water spring	664	7.72
	Rain water collection	393	4.57
	Other source	239	2.78
PHC has sewerage	No (Ref.)	2826	32.86
	Yes, closed	3868	44.98
	Yes, open	1905	22.15
Clean toilet with running water is available	No (Ref.)	2195	25.53
	Yes	6404	74.47
24-hour power supply	No (Ref.)	1261	14.66
	Yes	7338	85.34

Variables	Categories	N	(%)
CHC has organisational structure	No (Ref.)	426	4.95
	Yes, made internally	3284	38.19
	Yes, made externally	4889	56.86
Availability of 2010 work plan	No (Ref.)	884	10.28
	Yes	7715	89.72
Number of sanitarians	None	1824	21.21
	One	4339	50.46
	Two or more	2436	28.33
Retribution from patients	No (Ref.)	2840	33.03
	Yes	5759	66.97
Logged of total allocated budget			
Laboratory services ('No' as reference category)	Provides routine blood test = 1, Yes	4010	46.63
	Provides routine urine test = 1, Yes	4091	47.58
	Provides blood glucose test = 1, Yes	4737	55.09
	Provides cholesterol test = 1, Yes	3037	35.32
	Provides faeces test = 1, Yes	2132	24.79
	Provides malaria blood test = 1, Yes	4656	54.15
Total		8599	100.00

With regards to spatial characteristics, the majority of PHCs are located in Java & Bali islands (40.42), the most densely populated region in Indonesia. Moreover, the PHCs predominantly located in rural areas (74.06%). Concerning remoteness, only 9.25% of PHCs are located in a very remote place, and 6.38% of PHCs are located on small islands. Regarding basic amenities, one in three PHCs have access to piped water connection, 83.70% have access to a water source with year-long availability, 44.98% have closed sewerage, 74.47% have a clean toilet with running water, 85.34% have a 24-hour power supply.

Factors Associated with Waste Segregation Practices in PHCs

Waste segregation at source is of importance to differentiate the characteristics of PHC waste to be categorised as medical or general wastes (Chartier *et al.*, 2014). Moreover, segregation practices will

determine appropriate treatment technology and final disposal (Chartier *et al.*, 2014). In this paper, PHC wastes were only segregated into two categories, namely medical and general wastes, regardless of the type of medical waste which needs to be contained separately, such as sharps waste.

Table 2 presents the results of waste segregation analysis accommodating all relevant variables sourced from the survey in Model 1. These included development region, the location of PHCs, remoteness of PHCs, main water source, ownership of sewerage system, availability of running water, existing of organisational structure, availability of 2010 work plan, allocated budget, and availability of particular laboratory services. Model 1 has Tjur's Coefficient of Determination of 24.30 per cent and area under the curve of 79.54 per cent; which means the model discriminates between segregation and non-segregation well.

Table 2. Regression results of waste segregation practices

Variables	Categories	OR	95% CI	
			Lower	Upper
Development region	Java & Bali Islands (Ref.)	1.000	-	-
	Sumatra Island	-0.189 ***	-0.215	-0.163
	Other regions	-0.254 ***	-0.281	-0.227
Location of PHC	Urban area (Ref.)	1.000	-	-
	Rural area	0.407 ***	0.357	0.465
Remoteness of PHC	Not remote (Ref.)	1.000	-	-
	Remote	0.749 ***	0.648	0.867
	Very remote	0.938	0.778	1.132
Main water source	Piped connection (Ref.)	1.000	-	-
	Bored well	0.820 ***	0.711	0.945
	Dug well	0.859 **	0.746	0.989
	Water spring	0.813 *	0.659	1.004
	Rain water collection	0.906	0.706	1.164
	Other sources	0.793	0.579	1.085
PHC has sewerage	No (Ref.)	1.000	-	-
	Yes, closed	2.412 ***	2.125	2.738
	Yes, open	1.887 ***	1.650	2.157
Clean toilet with running water is available	No (Ref.)	1.000	-	-
	Yes	1.457 ***	1.293	1.642
PHC has organisational structure	No (Ref.)	1.000	-	-
	Yes, made internally	1.320 **	1.036	1.681
	Yes, made externally	1.583 ***	1.241	2.019
Availability of 2010 work plan	No (Ref.)	1.000	-	-
	Yes	1.361 ***	1.149	1.612
Logged of total allocated budget		1.057 *	0.997	1.121
The laboratory provides cholesterol test service	No (Ref.)	1.000	-	-
	Yes	1.263 ***	1.116	1.429
The laboratory provides stool test service	No (Ref.)	1.000	-	-
	Yes	1.529 ***	1.332	1.754
Number of observations		8,599		

Notes: Ref. = reference category; PHC = public health centre; OR = odds ratio; CI = confidence interval; Constant is not shown; The model is overall significant at $p < 0.001$

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Factors Associated with the Method of Final Disposal of Medical Waste

Managing healthcare waste is vital in protecting public health. In general, there are seven ways in which this can be achieved. This type of management is known as the waste-management hierarchy which ranks the methods based on their environmental impacts, health impacts, financial affordability, and social acceptability (Chartier *et al.*, 2014). According to Chartier

and colleagues (2014) prevention of waste is a preferable method for waste management, while disposal is the least one. In the 2011 Rifaskes, information on the final disposal of medical wastes was only collected from PHCs that report segregating waste. Hence, the analytic sample for Model 2 is 5,591 PHCs. Table 3 presents the regression results of the factors associated with the method of final disposal of medical waste in the form of RRR and its 95 per cent CI.

Table 3. Regression results of final disposal method of medical waste

Variables	Categories	Open burning		Buried without burning		Other	
		RRR	95% CI	RRR	95% CI	RRR	95% CI
Development region	Java-Bali Islands (Ref.)	0	-	0	-	0	-
	Sumatra Island	2.078 ***	1.725 - 2.502	3.651 ***	2.582 - 5.161	0.710 *	0.488 - 1.034
	Other region	2.504 ***	2.007 - 3.124	4.901 ***	3.351 - 7.169	0.540 **	0.334 - 0.874
Location of PHC	Urban area (Ref.)	0	-	0	-	0	-
	Rural area	5.100 ***	4.370 - 5.951	5.287 ***	3.831 - 7.296	0.603 ***	0.457 - 0.796
Remoteness of PHC	Not remote (Ref.)	0	-	0	-	0	-
	Remote	1.379 **	1.063 - 1.788	1.178	0.792 - 1.751	0.603	0.308 - 1.180
	Very remote	1.201	0.804 - 1.794	1.346	0.777 - 2.333	0.596	0.231 - 1.540
PHC located on a small island	No (Ref.)	0	-	0	-	0	-
	Yes	1.479 **	1.011 - 2.164	1.444	0.818 - 2.550	2.229 **	1.168 - 4.253
Year-long availability of water	No (Ref.)	0	-	0	-	0	-
	Yes	0.747 **	0.597 - 0.936	0.680 **	0.479 - 0.966	1.199	0.720 - 1.996
Main water source	Piped water (Ref.)	0	-	0	-	0	-
	Bored well	1.059	0.905 - 1.239	1.308	0.947 - 1.807	1.261	0.938 - 1.696
	Dug well	1.188 **	1.006 - 1.402	1.504 **	1.096 - 2.064	1.121	0.782 - 1.608
	Water spring	1.458 **	1.043 - 2.037	1.655 *	0.982 - 2.790	2.151 **	1.099 - 4.211
	Rain water collection	2.139 **	1.136 - 4.027	3.728 ***	1.770 - 7.850	2.915 *	0.819 - 10.375
	Other source	1.018	0.633 - 1.638	1.377	0.624 - 3.041	2.098 *	0.910 - 4.839
PHC has sewerage	No (Ref.)	0	-	0	-	0	-
	Yes, closed	0.788 ***	0.666 - 0.934	0.876	0.647 - 1.186	0.816	0.595 - 1.118
	Yes, open	0.880	0.723 - 1.072	0.950	0.684 - 1.321	0.808	0.543 - 1.200
Clean toilet with running water	No (Ref.)	0	-	0	-	0	-
	Yes	0.812 **	0.683 - 0.965	1.158	0.851 - 1.577	0.707 **	0.508 - 0.984
24-hour power supply	No (Ref.)	0	-	0	-	0	-
	Yes	0.753 *	0.546 - 1.038	0.684 *	0.439 - 1.065	0.350 ***	0.193 - 0.635

Table 3. (continued)

Variables	Categories	Open burning		Buried without burning		Other	
		RRR	95% CI	RRR	95% CI	RRR	95% CI
Number of sanitarians	None	0	-	0	-	0	-
	One	0.685 ***	0.572 - 0.819	0.677 **	0.492 - 0.930	0.411 ***	0.303 - 0.557
	Two or more	0.652 ***	0.526 - 0.808	0.638 **	0.443 - 0.917	0.676 **	0.464 - 0.986
Retribution from patients	No (Ref.)	0	-	0	-	0	-
	Yes	0.987	0.848 - 1.148	0.855	0.659 - 1.108	0.899	0.648 - 1.247
Logged of total allocated budget	±	0.877 ***	0.818 - 0.940	0.926	0.809 - 1.060	0.830 **	0.720 - 0.958
Laboratory services	No (Ref.)	0	-	0	-	0	-
	Provide routine blood test = 1, Yes	0.721 ***	0.588 - 0.882	0.967	0.652 - 1.434	0.806	0.530 - 1.225
	Provide routine urine test = 1, Yes	1.244 **	1.003 - 1.544	0.825	0.545 - 1.247	0.996	0.647 - 1.533
	Provide blood glucose test = 1, Yes	0.809 **	0.684 - 0.958	0.789	0.579 - 1.075	0.992	0.717 - 1.373
	Provide feces test = 1, Yes	0.736 ***	0.624 - 0.868	0.631 ***	0.446 - 0.892	0.654 **	0.461 - 0.926
	Provide malaria blood test = 1, Yes	0.901	0.767 - 1.058	0.826	0.619 - 1.104	0.635 ***	0.465 - 0.867
Number of observations		5591		5591		5591	

Notes: Ref. = reference category; PHC = public health centre; RRR = relative risk ratio; CI = confidence interval; Constant is not shown; The model is overall significant at $p < 0.001$; The reference category for the dependent variable of for the model is incineration.

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

DISCUSSION

Waste Segregation

It is observed that around two-thirds of PHCs reported segregating their medical wastes (64.98%; 5,588 PHCs), which means that many PHCs disposed of their medical waste along with municipal waste. Segregation is the most crucial phase of waste management in healthcare facilities. It is the process of separation of different types of PHC waste by sorting it into designated categories according to WHO guidelines as to differentiate the risks and to accommodate the appropriate treatment technology (Chartier *et al.*, 2014). However, the study revealed that many PHCs did not practise segregation at source. Non-segregation practice led to the mixture of general waste and hazardous waste. Consequently, all the waste become hazardous waste and it will increase the cost of treatment.

More importantly, the hazardous waste generated by PHCs could contaminate the PHCs' environment and spread hazardous related diseases, such as blood-borne diseases. This health impact would pose not only a risk to the PHCs' health professionals but also the general population who contact with the waste directly or indirectly through the contaminated environment. Therefore, the segregation practices at waste sources should be the most intervention as to improve the waste management at Indonesian PHCs, before selection and the provision of appropriate technology. This condition is similar to other developing countries which have poor practices of HCWM (Alves *et al.*, 2014; Chartier *et al.*, 2014; Mmereki, Baldwin, Li, & Liu, 2017). Moreover, the segregation practices did not consider errors in determining various types of medical wastes, resulting in an overestimation of medical wastes contained. This mistake also happened in Brazil when a similar study found that personnel of PHCs put general waste into medical waste containers, indicating poor knowledge of segregation of waste operators (Alves *et al.*, 2014).

Basic Amenities

Inadequate water, sanitation and environmental conditions of health facilities

may exert adverse health effects especially on vulnerable populations such as immunocompromised persons, pregnant women, and infants (Allegranzi *et al.*, 2011; Cronk, Slaymaker, & Bartram, 2015; Prüss-Ustün *et al.*, 2019; WHO, 2011; WHO & UNICEF, 2015). Also, the lack of adequate water and sanitation hinders health facilities to prevent and control infections, which can be done through proper waste management (WHO & UNICEF, 2015). Therefore, it is important to consider the basic amenities of PHCs. The variables describing basic amenities of PHCs were the main source of water, sewerage system, and availability of toilet. With regard to water source, it is found that PHC with water spring, bored well, or dug well as main water source were found to be less likely to segregate medical waste, with OR of 0.81 (95% CI: 0.65–0.99), 0.82 (95% CI: 0.71–0.94), and 0.85 (95% CI: 0.74–0.98), respectively. Once again, this condition reflects the level of resource available for maintaining environmental health status. However, no studies were dealing with the relationship of healthcare waste segregation and basic amenities of PHCs. Nevertheless, this finding indicated that basic amenities should be a prerequisite of environmental health facilities in a good PHC.

Concerning sewerage, it is observed that PHCs with open sewerage system were more likely to practice segregation than those that do not have any sewerage system (OR: 1.89; 95% CI: 1.65–2.16). Moreover, PHCs with closed sewerage system were more likely to practice segregation than those that do not have any sewerage system (OR: 2.43; 95% CI: 2.14–2.75). As for the toilet, PHCs that have toilet was found to be more likely to segregate medical waste than those that do not (OR: 1.46; 95% CI: 1.30–1.64). This variable also confirms that such an important facility can be a proxy for the implementation of other sanitation practices.

Management and Planning

The variables intended to depict management of PHCs were organisational structure and work plan. Regarding the structure of the organisation, PHCs with

internally made one were found to be more likely to segregate waste than those that do not have any (OR: 1.32; 95% CI: 1.04–1.68). Moreover, PHCs with externally made one were found to be more likely to segregate waste than those that do not have any (OR: 1.59; 95% CI: 1.25–2.03). Regarding the work plan, PHCs that own one were found to have higher odds of segregation than those that do not (OR: 1.38; 95% CI: 1.16–1.63). This finding is consistent with the study by Irianti et al. (2013) which observed that having a waste management plan increases the likelihood of hospitals segregating waste into three or more types. As for budget, it was found to be positively associated with higher odds of medical waste segregation. This finding is also consistent with the findings of Irianti et al. (2013). Furthermore, the results of a study in Lao PDR also similarly confirmed this study by revealing that availability of waste facilities and instructions for segregation, collection and transport would encourage waste segregation practices (Phengxay *et al.*, 2005). The importance of management and planning of PHC wastes was also stated in WHO (2005) since this variable can be considered as a proof of the availability of regulation and policy in healthcare waste management. Dealing with the risks confronted by health professionals or PHC communities, the PHC managers should provide appropriate measures as to protect their personnel from suffering blood-borne diseases by giving hepatitis B vaccination. Moreover, since PHCs also generated a fraction of used syringes, post-exposure prophylaxis should be in place to overcome sharps injury's impacts.

Overall, the owners of the PHCs which are usually local governments should reevaluate the management of PHCs including their proper waste management in line with the implementation of UHC as to improve healthcare services as well as to protect their communities from hazardous waste-related diseases. This action can be implemented by establishing a unit at each PHC with sufficient funds followed by regular training concerning proper HCWM based on available regulations and policies provided by the central government based on WHO guidelines. Without reassessment of

the existing conditions of PHCs, the PHCs remain as harmful places for patients, health personnel and the general population.

Laboratory Services

The variables indicating services provided were cholesterol test and faecal test. It is observed that PHCs that provide cholesterol test were more likely to segregate medical waste than those that do not (OR: 1.28; 95% CI: 1.13–1.45). Moreover, it is also observed that PHCs that provide faecal test were more likely to segregate medical waste than those that do not (OR: 1.55; 95% CI: 1.35–1.78). This result suggests that laboratory services will generate more medical waste than those that do not, as such there is a need to manage the waste produced by segregating to reduce the amount of medical waste.

Final Disposal of Medical Waste

It is observed that almost half of the PHCs in the analytic sample reported opting to burn their medical waste in the open. This pattern is similar to practices in Adama, Ethiopia (Hayleeyesus & Cherinete, 2016). However, this situation is very different from what the WHO recommends. Disposal of medical waste should be thoroughly considered even from the very start of treating a patient (Chartier *et al.*, 2014). It should be segregated and collected in a specially labelled waste container, different from that are used for general waste. For instance, sharps containers are used to collect used syringes. As such, improper disposal methods undermine the benefits of medical waste segregation in the first place.

Geographical Characteristics

The spatial variables in this paper were the development region, rurality, remoteness, and located on a small island. It is observed that PHCs located in Sumatra and Other Region have higher odds of burning wastes in the open than using incinerators, compared to PHCs located in Java-Bali Region. Likewise, PHCs located in rural areas, compared to their urban counterparts,

are also found to be more likely to burn their waste openly than using an incinerator. Similarly, when a PHC is located in a remote area or on a small island, it has a higher likelihood of burning in the open than using an incinerator. This result also indicated the occurrence of disparities between urban and rural areas concerning the provision of waste management facilities.

Basic Amenities

Concerning the basic amenities of PHCs, the statistically significant variables were the year-long availability of water, the main source of water, sewerage system, clean toilet with running water, 24-hour power supply. It is observed that PHCs with a year-long availability of water, compared to those that do not, were less likely to burn their wastes in the open than using incinerators. Moreover, it is found that PHCs that used dug well, water spring, and rainwater as the main water source, were more likely to practice open burning of wastes, compared to those that have piped connection. Regarding sewerage, both PHCs with closed and open sewer system are less likely to burn their waste openly, compared to those with no sewerage. Furthermore, PHCs that have a reliable power supply and toilet with running water are found to be less likely to practice open burning compared to using incinerators. These indicated that the higher the level of environmental health facilities and practices, the higher the practices of medical waste treatment and disposal.

Human Resource

The only significant human resources variable was the number of sanitarians. It is observed that PHCs with sanitation workers were less likely to burn their medical waste in the open than using incinerator. This finding can be argued that sanitarians have sufficient knowledge of environmental health including various types of waste disposal technologies to choose. Moreira and Günther (2013) also found the similar findings when PHCs lacked professional staff; the PHCs tended to practice open burning instead of incineration technology. Moreover, continual training of staff assigned to HCWM in health

facilities is essential to maintain and improve their performance over the time (Shivalli & Sanklapur, 2014). These training should include materials to improve health workers' behavioural control and intention to improve their willingness to practice waste segregation (Akulume & Kiwanuka, 2016).

Management and Planning

The variables representing management and planning are retribution collection and allocated budget. Collecting retribution from patients is not significantly related to the method of final disposal of medical wastes. As for the total allocated budget, it is found the higher value of which is significantly associated with lower likelihood of practising open burning compared to using incinerators. This finding means that the availability of sufficient funds will promote better options for waste disposal methods.

Laboratory Services

The variables related to services provided in the PHCs that were statistically significant were routine blood test, routine urine test, blood glucose test, faeces test, and malaria blood test. However, the direction of the associations was mixed. This finding was also linear to the result of Model 1, since the better the segregation put in place, the better the final disposal method of segregated waste chosen.

Limitations and Strengths

This paper has several limitations. First, the structure of the 2011 Rifaskes questionnaire has deficiencies. As this paper is a further analysis of the 2011 Rifaskes, these shortcomings cannot be altered. One example is information on the final disposal of wastes was only collected from PHCs that segregates wastes. Second, the statistical models in this paper do not take into possible account endogeneity of the explanatory variables. This drawback may have caused underestimation or overestimation of the coefficient of the explanatory variables. Lastly, the information collected in the 2011

Rifaskes may be outdated as it was conducted seven years ago. However, this study is a cross-sectional study of factors associated with waste management. Moreover, as previously mentioned, the GoI has not conducted a new census, and there are no comparable data on health facilities at the national scale in Indonesia. Hence, the 2011 Rifaskes data is still appropriate. Nonetheless, these limitations should be kept in mind when interpreting the results.

Despite the limitations mentioned earlier, this paper has several advantages. First, to the best of our knowledge, this paper is the first to investigate the factors associated with waste segregation and final disposal in PHC settings. Second, this study uses data from a census of government PHCs, so the results represent the status of PHCs waste management at the national level.

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

This paper investigated the factors associated with medical waste segregation and methods of final disposal using data from the 2011 Rifaskes. The findings of this study will be of importance to guide policymakers in improving the current conditions of PHCs in Indonesia in the era of UHC, especially in providing environmental health facilities to prevent the spread of diseases and the occurrence of injury.

It is found that several explanatory variables were influential in determining the likelihood of PHCs waste segregation and disposal. Both the multivariate regression analyses suggest that there are geographically based inequalities in medical waste segregation and final disposal method. PHCs located in JavaBali region, in an urban area, not in the remote area, in main islands are more likely to practice medical waste segregation, and less likely to practice open burning. PHCs that own a sewerage system is also more likely to practice medical waste segregation, and less likely to burn their medical waste openly. Moreover, PHCs with better basic amenities (i.e. water supply, sanitation, and electricity) are more likely to

segregate their waste and less likely to burn their medical wastes openly. The overall results of the study confirmed the existence of inequalities in healthcare waste management that needs to be adequately addressed by stakeholders in waste and health sectors.

Recommendations

In the light of the findings, the following recommendations can be drawn. The availability of regulation and policy in healthcare waste management should be implemented and enforced to ensure that conservation of the environment and protection of public health are the ultimate goals of healthcare waste management. These can be done by regularly promoting waste segregation at the point of generation in PHCs to ensure sustainable HCWM. This promotion should be combined with sufficient resources such as trained personnel, colour-coded bins and standard operating procedures. Second, the use of non-incineration technologies for the final disposal of medical wastes should be promoted and scaled up to reduce its inequalities and minimise health risks of dioxins and furans as recommended by the World Health Organization. It is recommended that all PHC staff should be immunised against Hepatitis B and provided with post-exposure prophylaxis of HIV to prevent waste handlers and operators from blood-borne diseases. Furthermore, new staff should be given training on management of healthcare waste as part of their induction programs.

Lastly, the government should provide more attention to PHCs located in rural area, remote area and less developed regions to improve public health protection in reducing inequalities. This solution can be done by providing those PHCs with affordable waste management methods.

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