



Assessing Ecological and Socio-Economic Attributes in Sustainable Management of Solid Medical Waste in Urban Environment

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ABSTRACT

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Unreliable system of solid waste management has hindered performance of public health system in developing countries. This condition was exacerbated by the covid-19 pandemic which posed risk to healthcare staff and public that makes the management of medical waste worsening. This study seeks to analyze the existing conditions of community health centre solid medical waste management from ecological, economic and social aspects in Pekanbaru and to design a solid medical waste management model for community health centres in Pekanbaru by identifying and quantifying ecological and socio-economic attributes to help solid medical monitor waste. A mixed method approach is used in this study with inferential analysis. Data analysis was used to analyze the relationship of ecological, economic and social factors to the management of solid medical waste at community health centres in Pekanbaru. The analysis process included univariate and bivariate analysis using a computerized program. The findings show that monitoring through the waste monitoring application can help monitor waste management in community health centres. As an implication, a solid medical waste management model can be used and implemented to support sustainable solid medical waste management.

1. INTRODUCTION

Environmental health problems are issues that receive considerable attention, especially during Covid-19 pandemic [1]. As disease can arise and infect humans as the effect of badly regulated environment, environmental health is a very important health issue [2]. Medical waste produced by health facilities is one of the biggest concerns in Covid-19 pandemic [3-6]. Infectious waste such as used facemasks, gloves, and personal protective equipment are hazardous and toxic waste and harmful to the environment [7, 8]. Currently, almost all over the world is experiencing an increase in the number of piles of infectious waste due to the handling of Covid-19 [9, 10]. During the pandemic, the increase in waste in Indonesia reached 30 percent to 50 percent. According to the Ministry of Environment and Forestry, during the pandemic that began to appear in March 2020 to February 4 2021, the amount of infectious waste was recorded at 6,417.95 tonnes [11].

The Pekanbaru Health Office noted that in 2019, 502 tons of medical waste had been produced by 30 hospital units and 21 community health centres. On average each month medical waste generated in Pekanbaru reaches 42 tons. Meanwhile, medical waste from community health centres in Pekanbaru was just over two tons each year. Hospitals contributed 376,089 tons/day of solid waste production and 48,985 tons/day of hospital liquid waste production in 2014 [12]. The health impacts that can be caused are mainly the spread of infectious diseases, especially nosocomial infections, which can become breeding grounds for vector bacteria that carry diseases. Human-induced greenhouse gas emissions and the

changeable pattern of global weather also exacerbated the effect of climate change that posed risk to food system and livestock production and the management of waste especially in developing countries [13].

Solid medical waste is important to manage because the volume of solid waste produced by health care facilities is higher than other waste. The accumulation of solid waste, infectious staff, environmental pollution, waste management that is not in accordance with procedures to the lack of infrastructure for solid waste management is a problem that arises in health care facilities such as community health centres and hospitals in developing countries [14]. Moreover, the Covid-19 pandemic exacerbated the conditions and posed risk to healthcare staff and public employee such as garbage truck workers that makes the management of medical waste worsening [15, 16]. In 2021, community health centres in Pekanbaru would only make efforts to separate waste so that waste does not accumulate in community health centres. However, the results of the researcher's interviews with several heads of community health centres in Pekanbaru, the third party managing medical waste only collects waste once a year at one of the Community health centres resulting in a build-up of waste which is very dangerous and poses a risk to the environment, officers and visitors to the community health centres. This is coupled with the problem of several community health centres which have problems with solid medical waste management infrastructure. This medical waste problem should quickly receive a serious and focused portion of treatment because the production of medical waste is increasingly becoming a serious threat to health workers,

patients and the surrounding environment [17]. This condition is a serious problem from an environmental health perspective. This research seeks to develop a solid medical waste management model through an application-based solid medical waste management monitoring method. This method measures the instrument quantitatively by identifying the conditions of waste management in each community health centre in Pekanbaru, Indonesia.

The content of this research was divided into some parts. The first was the introduction mainly discussing the background and the relevance of research. The second part was research method discussing the design, approach, and techniques used to collect the data and the analysis in this study. The third part was the main part of this research, explaining the research results regarding ecological and socio-economic attributes in sustainable management of solid medical waste in Pekanbaru. The following part was discussion to justify the findings with previous research. The last part was conclusion to elaborate main findings, implications, dan recommendation obtained from the findings.

2. RESEARCH METHODS

The design used in this research is exploratory sequential design. The exploratory sequential design carried out by collecting quantitative data based on the results of the first stage. In testing the identification and quantification of ecological and socio-economic attributes that would be integrated in a network, it is carried out by several local staff

who are in charge of inputting data and staff who are in charge of monitoring the process of transferring data from the monitoring location to the monitoring centres.

The sample in this study were 21 community health centres or 42 people and total sampling was taken, where this type of sampling was carried out in each population. The method is purposive sampling method by taken two representatives from each of 21 community health centres. Secondary data was obtained by examining existing documents at community health centres, namely community health centre policy documents related to medical waste management, community health centre profiles, environmental health program reports at community health centres, as well as other supporting data from other sources. Based on the variables that would be discussed in this study, namely waste management, ecology, economics, and social, the operational concept is shown in Table 1.

The mixed method approach in this study uses inferential analysis. Data analysis was used to analyze the relationship of ecological, economic and social factors to the management of solid medical waste at community health centres in Pekanbaru. The analysis process would include univariate and bivariate analysis using a computerized program. Bivariate analysis, namely the complete data that has been collected is tabulated into a table according to the variable to be measured. Bivariate analysis is used to determine the relationship between independent variables (ecological, economic, social) to the dependent variable. The statistical test used in this research is the Chi Square test with a Confidence Interval of 95% and $\alpha=0.05$ to determine a single relationship.

Table 1. Operational definition

Variable	Concept	Item	Measuring instrument	Data Scale	Results Measure
Waste Management	Activities carried out to achieve a clean and healthy community health centre through the handling of solid medical waste originating from health services;	<ul style="list-style-type: none"> - Sorting - Storage - Collection - Transportation - Disposal/Destruction 	Observations, Interviews and Questionnaires	Ordinal	Medical waste management activities: Good ≥ 3 Low < 3
Ecology	Availability of warehouse is in accordance with standards and the correct storage flow	<ul style="list-style-type: none"> - safety boxes in every room that produces hazardous medical waste - standard personal protective equipment - officers used protective equipment when making contact with waste 	Short interviews, questionnaires and observations with a checklist	Ordinal	Medical waste management activities: Good ≥ 3 Low < 3
Economy	improvements of economic utility related to solid medical waste management in community health centres	<ul style="list-style-type: none"> - Operational funds - funds for procurement of equipment 	Interviews, questionnaires and observations	Ordinal	Available = 1 Unavailable=0
Social	Knowledge related to solid medical waste management in community health centre	<ul style="list-style-type: none"> - Attitude of officers in managing solid medical waste - Action of officers in managing solid medical waste <p>Education level of heads of community health centres</p>	Questionnaire	Ordinal	Medical waste management activities: Good ≥ 3 Low < 3

3. RESULTS

The descriptive statistical test of this research is used to provide information about the research variables. Descriptive statistics for the research variables can be seen in Table 2.

Table 2 showed that community health centres that carry out waste sorting should mostly do waste sorting, namely 11 community health centres or 52.4%. Sorting is done starting from the trash in each room. There are still 10 community health centres that do not sort solid medical waste, meaning that community health centres only sort medical waste, such as needles in safety boxes, while masks, gloves and other personal protective equipment are still disposed of together with non-medical waste. Then the storage of solid medical waste is carried out in the waste building with a capacity of up to 100-200 kg. This capacity is not so much because indeed when it has accumulated it is transported by a third party. The conclusion that can be drawn from the paragraph above is that some community health centres in Pekanbaru are categorized

as having good waste management. Storage of solid medical waste in waste buildings with the amount of waste stored per year reaching >200 kg in 13 community health centres or 62.9%. If we look back at this amount of waste, it exceeds the capacity of the community health centres' solid medical waste shelters.

Table 3 shows that the majority of community health centres have waste warehouses, namely 16 community health centre or 76.2%, and there are still 5 community health centres or 23.8% of community health centres that do not yet have a waste building specifically for solid medical waste.

Table 4 showed that community health centres as a whole have a budget for solid medical waste management. This solid medical waste management fund is a fund for the transportation of solid medical waste. For other funds such as the construction of temporary shelter buildings, the purchase of personal protective equipment and others cannot be accommodated by Community health centres due to limited funds.

Table 2. Waste management indicators in Pekanbaru community health centres

Indicators	N	%	Indicators	N	%
<i>Waste sorting:</i>			<i>Waste Disposal:</i>		
Yes	11	52.4	Yes	0	0
No	10	47.6	No	21	100
<i>Waste storage:</i>			<i>Warehouse capacity:</i>		
Yes	10	47.6	< 100 kgs	12	57.1
No	11	52.4	> 100 kgs	9	42.9
<i>Waste collection:</i>			<i>Annual waste stored</i>		
Yes	9	42.9	100-200 kgs	8	38.1
No	12	57.1	> 200 kgs	13	62.9
<i>Waste transportation:</i>			<i>Waste management:</i>		
Yes	21	100	Good	12	57.1
No	0	0	Low	9	42.9

Table 3. Ecological indicators in Pekanbaru community health centres

Indicators	N	%
<i>Waste Warehouse:</i>		
Available	16	76.2
Unavailable	5	23.8
Total	21	100
<i>Safety box:</i>		
Available	21	100.0
Unavailable	0	0.0
Total	21	100
<i>Personal Protective Equipment:</i>		
Fully Available	9	42.9
Incomplete	12	57.1
Total	21	100

Table 4. Economic indicators in Pekanbaru community health centres

Indicators	N	%
<i>Fund for Waste Management:</i>		
Available	21	100
Unavailable	0	0
Total	21	100

Table 5 shows that most of the community health centres have environmental health workers with good knowledge, around 52.4% or 11 community health centres and 10 community health centres or 47.6% with less knowledge. The attitude of environmental health officers was assessed as good

at 12 community health centres or 57.1%. And the lack of attitude amounted to 9 officers or 42.9.

Next, bivariate analysis is an analysis used to determine the relationship between the independent variables and the dependent variable. Bivariate analysis would describe whether

there is a relationship between each variable.

Based on the bivariate analysis as shown in Table 6, it was found that the p value <0.05 means that there is a relationship

between ecological, economic and social factors with the management of solid medical waste in Pekanbaru community health centres.

Table 5. Social indicators in Pekanbaru community health centres

Indicators	N	%
<i>Knowledge:</i>		
High	11	52.4
Low	10	47.6
Total	21	100
<i>Attitude:</i>		
High	12	57.1
Low	9	42.9
Total	21	100
<i>Action:</i>		
High	21	100
Low	0	0
Total	21	100

Table 6. Bivariate analysis

Variable	p-value	OR
Ecology	0.032	0.275 (0.087-0.875)
Economy	0.003	0.139 (0.024-0.679)
Social	0.008	0.187 (0.057-0.774)

4. DISCUSSION

Based on the bivariate analysis, it was found that the p value <0.05 means that there is a relationship between ecological, economic and social factors with waste management in Pekanbaru community health centres. Ecology is a science that studies the interrelationships between organisms and some of their environmental factors. Ecology would become a system and influence each other with the levels of living things, namely populations, communities and ecosystems. Ecology and ecosystem with its various constituent components such as abiotic and biotic factors are an inseparable part in solid waste management [18]. Abiotic factors include temperature, water, humidity, light and topography while biotic factors are living things which include humans, animals, plants and microbes. Furthermore, ecology is a process that regulates the diversity and distribution of species of organisms, so that ecological factors play a very important role in the management of solid medical waste which is related to the spread of viruses and bacteria to the environment [19].

Economic factors are internal factors that influence economic activities or businesses in meeting the daily needs of life to achieve wellbeing. Economic factors in community health centres are closely related to the budgeting of funds in the planned budget for all community health centre activities, especially solid medical waste management activities [20, 21]. The importance of this economic factor relates to the procurement of physical things that support solid medical waste management activities in community health centres. The budget includes the construction of waste buildings, transportation services and complete personal protective equipment.

The next social factor is an important factor in determining the course of solid medical waste management activities.

Social factors are a group of people who closely consider similarities in formal and informal community status or rewards [22]. Social factors can be seen from relationships with friends, family and parents in influencing the course of activities [23, 24]. In this study, the social factors directly involved in solid medical waste management activities were the head of the community health centres as the leader, environmental health officer as the person in charge of the program in charge of the community health centre solid medical waste management. Overall, the two parties have synergized to maximize the management of solid medical waste in community health centres, but there are still many obstacles encountered. The results of this study are in line with Tabrizi et al. [25] who conducted research on solid medical waste management in community health centres in Iran. This was also in line with Mesdaghinia et al. [26] regarding the analysis of solid medical waste management in community health centres.

The process of managing solid medical waste in community health centres, which according to regulations must use an incinerator that has the capacity to destroy infectious waste, not all community health centres do this. Community health centres can carry out the final handling of solid medical waste using an incinerator. Meanwhile, community health centres carry out the final handling of solid medical waste by incinerating it in a 40 cm diameter barrel and not using an incinerator. This is in line with Patil and Pokhrel [27] showing biomedical solid waste management in an Indian hospital and its mandatory compliance with applicable regulation. Suryawan et al. [28] found the use of incinerator in processing solid medical waste management in community health centres.

The solid medical waste management model for community health centres in Pekanbaru is using a quantification model of ecological and socio-economic attributes. Quantification is

useful as a form of solution which is urgently needed at this time considering that almost all community health centres in Pekanbaru produce waste that exceeds the capacity of the waste warehouse. The quantification of attributes designed and recommended in this study is the result of a synthesis of empirical findings as well as from theories and concepts in previous studies. This application would bring up a comparison of the capacity of the waste warehouse with the amount of waste collected, and would automatically give warnings to community health centre officers, the health department and third parties regarding the amount of waste. Furthermore, from the notification of periodic waste capacity, the 3rd party would immediately pick up waste at community health centres that have exceeded the maximum capacity of the waste warehouse. In this application, the officer only inputs an update on the amount of waste collected on a regular basis. Thus, it is hoped that there would be no more accumulation of solid medical waste in Pekanbaru community health centres.

The results highlight that community health centres are one of the waste-producing health installations that have an

obligation to protect the environment and public health, and have special responsibilities related to the waste that is produced. The obligations referred to include the obligation to ensure that the handling, processing and disposal of waste would not have an adverse impact on health and the environment [29]. The main characteristic of health care waste is the presence of medical waste and non-medical waste. Medical waste is waste originating from medical service activities. Various types of medical waste generated from service activities in community health centres can be harmful and cause health problems, especially during collection, sorting, storage, storage, transportation and destruction as well as final disposal [30].

Finally, the findings lead to the formulation of Strengths, Weaknesses, Opportunities, and Threats of medical waste management, or what is known as a SWOT analysis of the analysis of problems revealed regarding medical waste management in existing in Pekanbaru. The SWOT analysis identified the internal factors (IFE) of community health centres as strengths and weaknesses, while external factors (EFE) as opportunities (Table 7).

Table 7. SWOT analysis

Internal Factors (IFE)	Weight	Ratings	Score	External Factors (EFE)			
Strength				Opportunities			
- Available safety box in every room	0.124	0.374	0.046	- Available sources of funds from BPJS Kesehatan	0.143	0.430	0.061
- Good officer's actions	0.122	0.368	0.045	- Good Accreditation	0.138	0.416	0.057
- Good attitude of the officers	0.120	0.362	0.043	- Health service support	0.134	0.402	0.054
- Regular collection	0.118	0.356	0.042	- Clear regulations and SOPs	0.099	0.199	0.019
- Waste disposal by 3 rd party	0.116	0.350	0.040	- Routine Monitoring by health agency	0.097	0.194	0.018
- Routine separation of waste	0.089	0.178	0.015	- Training by the health office	0.094	0.189	0.018
- Routine sheltering	0.087	0.174	0.015	- Socialization of the latest regulations	0.092	0.185	0.017
- Good staff knowledge	0.085	0.170	0.014	- Regular monitoring by the health office	0.090	0.180	0.016
- Good officer education	0.083	0.166	0.013	- Supporting facilities	0.060	0.060	0.003
- Regular officer training	0.051	0.051	0.002	- Health department budget	0.048	0.048	0.002
Total	1	2.552	0.281	Total	1	2.307	0.269
Weakness				Threat			
- Lack of periodic monitoring	0.047	0.047	0.002	- Threats to visitors	0.500	0.500	0.250
- Incomplete use of personal protective equipment	0.076	0.153	0.011	- Threats to the environment	0.076	0.076	0.005
- insufficient operational funds	0.082	0.164	0.013	- High cases of Covid-19	0.880	0.880	0.774
- Lack of SOP implementation	0.097	0.195	0.019	- Densely populated location	0.916	0.916	0.840
- Lack of repair funds	0.111	0.333	0.037	- Lack of 3 rd party coordination	0.080	0.080	0.006
- Lack of procurement funds	0.113	0.339	0.038	- The transfer of officer	0.083	0.083	0.006
- Not having routine waste transporting	0.114	0.344	0.039	- Threats to health workers	0.087	0.087	0.007
- excessive capacity of Waste production	0.116	0.350	0.040	- Feedback from BPJS Kesehatan	0.146	0.292	0.042
- Unstandardized waste warehouse	0.118	0.356	0.042	- Limited 3rd parties' options	0.146	0.292	0.042
- Limited human resources	0.120	0.362	0.043	- Many external parties monitor	0.153	0.306	0.047

Solid medical waste originating from health care facilities has an impact on health and the environment. Therefore, the management of solid medical waste in community health centres needs serious attention. Management of medical waste in community health centres has complex problems. This waste needs to be managed in accordance with existing rules so that environmental management must be carried out in a systematic and sustainable manner. Planning, implementation, continuous improvement of the management of community health centres must be carried out consistently. In addition, human resources who understand environmental problems and

management are very important to achieve good environmental performance [31, 32]. The success of the management staff's actions is strongly influenced by the knowledge and attitudes of the workforce. The findings emphasized the planned behaviour as the critical factors in managing solid medical waste [33-35], and stakeholder role in the medical waste management [36-38], as well as the crucial role of human resources in healthcare waste management [39-41]. The findings also pointed out the importance of public sector transformation and technology-driven waste management for healthcare facilities [42].

5. CONCLUSION

The findings show the current condition where most of the Pekanbaru Public Health Centres have sufficient human resources, where all community health centres have policies/SOPs related to solid medical waste management. Infrastructure facilities are still insufficient, but all health centres have separated solid medical waste. Furthermore, temporary storage or waste storage is deemed inappropriate and some community health centre environmental health programs have been achieved which can manage solid medical waste properly. The results of the bivariate analysis obtained a p -value <0.05 meaning that there is a relationship between human resources, policies/SOPs, infrastructure, sorting, temporary storage, output and waste management in Pekanbaru community health centres.

As an implication, related institutions should socialize waste monitoring applications through quantification of ecological and socio-economic attributes to help monitor waste management in Pekanbaru community health centres. In addition, it is necessary to implement a solid medical waste management model by the Pekanbaru Health Office and continue in all Pekanbaru community health centres.

The findings have some limitations such as the lack of quantitative measurements in explaining ecological and socio-economic indicators from public health domain. Other limitations include the sampling technique and the lack consideration of stakeholder involving in waste supply chain management. This is highly needed to consider as waste management involve many parties. Thus, future research needs to widen sample size with larger sample in order to get generalizability of the findings. Future studies were also suggested to provide quantitative measures for variable used in solid waste management in urban area as it is considered able to reflect reliable findings obtained from statistical output.

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