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RESEARCH ARTICLE

DETERMINATION OF THE BEST METHOD FOR SAFE HANDLING AND RECYCLE-REUSE OF  
CLINICAL SOLID WASTE MATERIALS IN A HOSPITAL OF PENANG ISLAND, MALAYSIA

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ABSTRACT

The Clinical solid waste management has been raised a significant problem in most developing countries including Malaysia. The main reason of the mismanagement of this type of wastes is the lack of effective waste management strategy that can be easily implemented during clinical solid waste handling, transport and final disposal. Aware of the significance of the issue, the study was conducted in the form of a case study in one of the largest healthcare facilities in Penang Island, Malaysia, namely, the Hospital Lam Wah Ee. It was found that the hospital has taken apposite steps in safe management of clinical solid waste within its premise that comply with the relevant Ministry of Health regulations of Malaysia. However, the clinical solid waste management at the hospital required trained clinical staffs, effective control and high financial investments. Despite the health risks and environmental impacts, clinical solid waste is still disposed through incineration. The present study revealed the urgency to adopt effective sterilization technology in clinical solid waste management. The clinical solid waste materials would be recycled and reused after it has been sterilized, which would minimize the waste generation as well as its disposable cost.

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INTRODUCTION

The safe management of clinical solid waste is considered as problematic due to its enormous volume of generation, serious negative impacts to human health and the environment as well as high disposal cost (Ananth *et al.*, 2010; Insa *et al.*, 2010; Moreira *et al.*, 2013; Bendjoudi *et al.*, 2009). With increasing number of healthcare establishments and advance medication in healthcare centres, the generation of clinical solid waste has rapidly increased (Ananth *et al.*, 2010; Coker *et al.*, 2009; Hossain *et al.*, 2011). The clinical solid waste results from various healthcare facilities such as including hospitals, clinics, veterinary facilities, private practices, home health care, clinical laboratories and research laboratories (Insa *et al.*, 2010; Marinkovi *et al.*, 2008; Pruss *et al.*, 1999). Numerous researches are being conducted worldwide in order to define good practice guideline and to provide the best technologies for proper disposal of clinical waste with minimal risks to human health and the environment (Bendjoudi *et al.*, 2009; Abd El-Salam, 2010; Hossain *et al.*, 2012; Shinee *et al.*, 2008).

Although significant improvements have been achieved, more are needed to alleviate infectious risks and environmental contaminations. Unfortunately, clinical solid waste management has received little attention in the developing countries despite the deadly health risks and potential environmental hazards (Coker *et al.*, 2009; Da Silva *et al.*, 2005). Da Silva *et al.* (2005) reported that most of the healthcare facilities in Brazil do not follow the legislation during handling clinical waste, though there is a national guideline available. The clinical waste was generally handled without any perspective and collected along with the municipal waste. Shinee *et al.* (2008) reported that clinical waste management in Ulanbaatar city of Mongolia is inadequate due to lack of a comprehensive policy and strategy in national level, inadequate knowledge and skills of health sector personnel and absence of environmentally sound technology for treating clinical solid waste. Nemathaga *et al.* (2008) found the major policy implementation gap between the national level and the generated clinical solid waste management practices by healthcare facility in South Africa. Improper source segregation and poor handling were observed during clinical waste management in the studied hospitals. The study also revealed that the segregation of clinical waste was not conducted as demanded by the government regulations

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(Nemathaga *et al.*, 2008). Taking into account in preserving human health and the environment, the World Health Organization (WHO) emphasizes the need of suitable guideline to safely deal with healthcare waste under the local conditions for each country (World Health Organisation, 2005). Since it is important to have specific regulations in order to provide appropriate healthcare waste management, many developing countries have started to devise best practices guidelines and legislations. For example, Malaysia has taken comprehensive steps to mitigate impacts with appropriate clinical solid waste management practices by developing and implementing appropriate laws and guidelines according to the recommendations by Ministry of Health (MOH), Malaysia (Kula Lumpur, 2009). The guidelines included the safety and health features in clinical solid wastes in order to protect healthcare staffs, waste collection workers, patients and the general public. These concerns have resulted in clinical waste management being classified the clinical solid waste as scheduled waste by the Environmental Quality (Scheduled Wastes) Regulations, 2005.

All clinical facilities in Malaysia are imposed to refer the guidelines during the handling and management of clinical solid wastes with complying the requirements of Environmental Quality (Scheduled Wastes) Regulations, 2005. The guideline has also suggested to enhance knowledge in all key aspects involve in the clinical waste management in order minimize clinical waste generation, promote research on the impacts and risk assessment of clinical waste to human health and the environment (MOH, 2009). A successful waste management plan depends on the data of waste generation source and how these wastes are managed at the source (Bendjoudi *et al.*, 2009; Da Silva *et al.*, 2005; Alagöz and Kocasoy, 2008; Bdour *et al.*, 2007; Cheng *et al.*, 2010). There is limited information available in literature on the status clinical solid waste management practices at its source in Malaysia. The present study was conducted in order to assess the shortcoming of the existing clinical solid waste management practices at its source level by looking at Hospital Lam Wah Ee (HLWE) in Penang Island, Malaysia. Moreover, the feasibility of recycling-reuse of clinical solid waste materials was also evaluated in this study.

## MATERIALS AND METHODS

### Site selection

Hospital Lam Wah Ee (HLWE), Penang, Malaysia was selected for the present study due to study reported that the Hospital embraces a well-established, self-sustaining recycling of waste materials with the proper segregation of the clinical solid waste following local regulations (Ananth *et al.*, 2010). Moreover, the HLWE has been elected as one of the good solid waste management practices hospitals in Malaysia by the Housing and local Government in 2008 (Source: Penang Economic Monthly, Volume 10, issue 11).

### Gathering of information

The study was conducted in October, 2012. The information gathered in the present study was obtained from site visits, interviews and survey questionnaires. A questionnaire and

accompanying letter were mailed to the hospital on June 2012, to collect the information on clinical waste generation, related information on clinical waste management practices and ethical approval to conduct the study. The questionnaire was designed based on healthcare waste management guideline and legislation of Ministry of Health, Malaysia (Kula Lumpur, 2009) and the World Health organization’s rapid assessment tool. It includes clinical waste generation, collection, separation, transportation, storage and final disposal. After the ethical approval has been achieved from the hospital ethical panel, it was conducted on-site visits in October, 2012 with the returned questionnaire to confirm the information given. The site visited was conducted daily. The clinical waste management status with regards to waste generation, segregation, collection, storage, transportation and disposal were determined during the site visits.

### Data Collections

Data on the average yearly clinical solid waste generation rate were obtained from the clinical waste collection record kept by the Department of Infection Control of the HLWE. The amount of daily clinical solid waste, non-clinical waste and recyclable waste generation were measured by weighing the waste during site visits. The waste measured on a daily basis for 7 days and the average was determined. The clinical solid waste was measured in the centralized storage room just before collection by the contractor for the final disposal. The amount of daily non-clinical waste generation was determined by weighing the waste. The amount of recyclable waste was determined on every Wednesday. The percentage distribution of the waste was determined as below:

$$\% \text{ Distribution of the waste} = \frac{W_{A,B,C}}{W} \times 100 \tag{1}$$

Subsequently, clinical solid waste generation rate was determined based on the daily weight per bed per day (kg/bed/day) by the following equation:

$$W = \frac{W_A}{n} (\text{kg/bed/day}) \tag{2}$$

where, ‘W’ is the weight of total healthcare waste. ‘W<sub>A</sub>’ is the weight of clinical solid waste (kg/day), W<sub>B</sub> is the non-clinical waste generation (kg/day), W<sub>C</sub> is the recyclable waste generation (kg/day), and ‘n’ was the number of beds in HLWE.

## RESULTS AND DISCUSSION

### Overview of the Clinical solid waste management in Hospital Lam Wah Ee

The Lam Wah Eye is one of the largest healthcare facilities in Penang. It is a private hospital, with 523 beds. It has 53 departments including a kitchen and 25 wards. It has close to 1500 permanent workers. It is estimated to have an average inpatient admission of 160 and outpatients 600 per day. It was found that HLWE is a trend-setter in effective healthcare waste management in terms of revenue generation from established

recycling system of recyclables (Ananth *et al.*, 2010). Waste management was practiced according to the guidelines and regulations set by the Ministry of Health and Department of Environment, Malaysia. The waste management practice was monitored by the Infectious Disease Control Department of the hospital. The hospital staff and nurses were found to be fully committed to the system in place in providing a clean environment for the public and patients. The overview of clinical solid waste management in HLWE is presented in Fig.2. Clinical staffs are trained. However, HLWE provided short-term training to all personnel before being involved in clinical waste handling to increase their awareness on infection risk during clinical solid waste handling. All clinical staff and nurses take the Hepatitis B vaccine once in 6 months.

categories: clinical waste, non-clinical waste (general waste) and recyclable waste. The clinical solid waste was segregated according to its level of infectious nature and sharp objects. The hospital used color coded, high-density plastic bags with Biohazard symbols for segregation of the clinical solid wastes at the patient care unit/ward. Non-clinical waste was segregated using ordinary black color plastic bag, whereas recyclable waste were placed using the green color plastic bag. The details segregation policy of the waste is shown in Table 1. The segregation of clinical solid waste from the patient care area was carried out by the hospital nurses, whereas the collection and storage were conducted by an outsourced company.



Fig. 1. Location of the Hospital Lam Wah Ee, Penang Island Malaysia

Table 1. Segregation of healthcare solid waste at HLWE, Penang Island Malaysia

Category of waste	Example	Segregation
Non-clinical waste	Healthcare waste that is not contact with patient care and not pose any hazard rather than recyclable waste such as discards paper, plastic etc.	Black color plastic bag
Infectious waste	Tissues, materials or equipment that has been in contact with patient care.	Yellow color plastic bag
Sharp	Syringes, needles, scalpels, blades, cartridges, broken ampules, spike of drip set	Sharp bin
Microbiological lab waste	Clinical waste generated from Microbiology Laboratory; highly infectious waste i.e. used culture plates & swab sticks.	Light blue color plastic bag, placed in yellow bag after autoclave
Pharmaceutical	Time expired-drugs, used vaccine vial, drugs that have been spilled or contaminated	Yellow color plastic bag
Recyclable waste	Book, magazine, office paper, newspaper, plastic and tin etc- those are not contacted with patient care and not pose any hazard.	Green color plastic bag

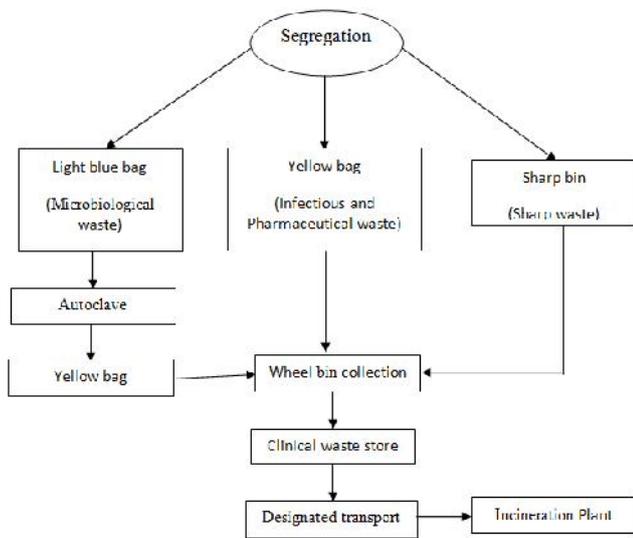


Fig. 2. Overview of Clinical Waste Management at the HLWE, Penang Island, Malaysia

Segregation of the Clinical Solid waste

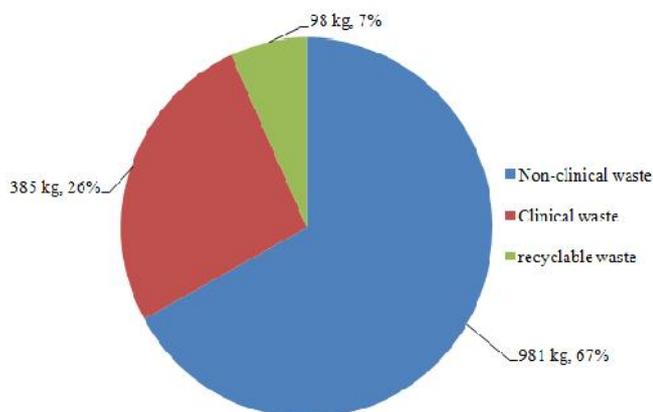
Waste segregation at its source is an essential element to minimize of the clinical solid waste generation. An effective segregation policy of clinical solid waste ensures that only that portion of healthcare waste requiring special treatment are treated (Bendjoudi *et al.*, 2009; Lee *et al.*, 2004). It was evident that the HLWE exercises effective segregation of clinical waste at source. Wastes generated from the wards were segregated according to its characteristics, into the following

Segregation of the different waste category is crucial to minimize clinical waste generation and to enable proper disposal. An effective segregation practice in a healthcare facility insures that the fractions of healthcare waste (i.e., Clinical solid waste) require special attention on handling and treatment is conducted. Segregation protects the general waste from mixing with the clinical solid waste; hence it saves the unwanted treatment cost. The improper segregation of clinical solid waste has been reported by various studies from the developing countries (Ananth *et al.*, 2010; Bendjoudi *et al.*, 2009; Patwary *et al.*, 2012). Studies are reported that clinical solid waste is being treated along with general waste (Ananth *et al.*, 2010; Alagöz and Kocasoy, 2008; Bdour *et al.*, 2007; Cheng *et al.*, 2010). Although, some of the healthcare facilities conducting the source segregation of the clinical waste, the waste is mixed with non-clinical waste during collection, storage and transportation. An effective segregation practice of

clinical solid waste requires proper awareness of clinical solid waste hazards, trained clinical staffs, and segregating materials. Inadequate segregation practice of clinical solid waste in developing countries was due to the absence of supportive materials for segregation and collection of the waste, lack of dedicated storage room for storage the segregated clinical solid waste and non-trained clinical staffs for handling the clinical waste (Bendjoudi *et al.*, 2009; Marinkovi *et al.*, 2008; Sawalem *et al.*, 2009). It was evident that the HLWE has conducted self sustaining clinical waste management practices following the effective source segregation and recycling program of general waste in accordance with the Ministry of Health regulation and guideline of Malaysia (Kula Lumpur, 2009). The finding of the present observation was strongly agreed with the study conducted by Anath *et al.* (2010). Ananth *et al.* (2010) determined the status of the healthcare waste management in 12 Asian countries namely Malaysia, Japan, China, Lao PDR, Vietnam, Thailand, Indonesia, Philippines, Singapore, Myanmar, Mongolia and Cambodia. The study reported that the HLWE embraces a special status healthcare waste management among the 12 Asian country's hospitals. The HLWE has established self sustain recycle program, segregation and collection of all categories of waste has been conducted adequately by following the Ministry of Health Regulation and guideline, Malaysia (Ananth *et al.*, 2010).

### Clinical Solid Waste generation

The amount of clinical solid waste generation at HLWE increased gradually with the increasing number of inpatients in the hospital. As it was evident from the hospital record, the amount clinical solid waste was 129,719 kg in 2007, and it was 142,192 kg in 2012. Wherein, the number inpatients were 32,404 and 36,926 in 2007 and 2012, respectively. Although, total clinical solid waste generation increased with increasing inpatients number, the average waste generation in per inpatient was found decrease in 2012 from 4.0 kg to 3.85 kg. This was due to the increasing concerns on the amount of wastes generated in the hospital. Besides, the segregation of recyclable materials might decrease the clinical solid waste generation in the hospital (Botelho, 2012). The percentage breakdown of the healthcare waste and its amount is shown in Fig.3.



**Fig. 3.** The amount of clinical, non-clinical and recyclable waste generation (kg/day), and their percentage distribution of generated waste in Hospital Lam Wah Ee, Penang Island, Malaysia

The percentage of clinical waste, recyclable waste and non-clinical waste composition were about 26%, 7% and 67%, respectively. The average clinical solid waste generation rate was estimated at 0.74 kg/bed/day, which is below the average clinical waste generation rate indicated by the Ministry of Health, Malaysia (0.8 kg/bed/day) (Kula Lumpur, 2009). Clinical waste generation rate in other South-East Asian countries like Thailand and Vietnam is 1.42 and 1.0 kg/bed/day, respectively (Taghipour *et al.*, 2009). The percentage clinical waste composition was found to be competitive with the clinical waste generation rate with other developing countries hospitals like South Africa 39% (Nemathaga *et al.*, 2008), Egypt 38.9% (Abd El-Salam, 2010), Bangladesh 36% (Kaisar Alam Sarkar *et al.*, 2006), Mongolia 29% (Shinee *et al.*, 2008). However, the proportion of clinical waste generation is highly depended on the waste management procedure followed by the hospital. The optimal waste generation could minimize by following an effective segregation of the waste materials (Ananth *et al.*, 2010; Tudor, 2007). The lower data on the percentage clinical waste composition in total amount healthcare waste in HLWE reveals that the HLWE has been conducting good waste management practice following to the effective source segregation of clinical solid waste and recycling-reuse program of general solid waste materials.

### Collection and Storage of clinical solid waste

The collection of clinical solid waste in HLWE was undertaken by two assigned individuals, one for pulling the cart and distributing empty polyethylene bags and the other for sealing the bags, putting the bags into the cart and replacing the bins with polyethylene bags. The staffs were aware of the potential hazards of clinical solid waste and were found to take requisite protective measures. They wore plastic aprons, sturdy gloves, masks and shoes during collection and transportation of the waste. They were found to take adequate precautions to prevent any spillage from the plastic bags. Cleaners from outsourced company and nursing assistants were responsible for the collection, internal storage and transport to external storage of the clinical solid wastes. There is an internal storage area located away from the wards and the nursing stations where the wastes were stored for not more than 16 hours. The clinical waste from the internal storage area is collected twice a day and transferred to a centralized storage area. It was found that internal transport routes (i.e., service lift or back door) were used during the transporting of the waste from internal storage area to centralized storage room to avoid the passage of waste within the wards and other clean areas, as shown in Fig.4a. Special bright yellow wheeled containers were used to transport the waste internally. The centralized storage room was well sanitized, secured and accessible to only authorized personnel. Moreover, the storage room was located away from the food preparation area and recyclable and non-clinical waste storage area. The room was air-conditioned, well ventilated and well lit with clear Biohazard symbols. The room was found to be sufficient for the storage of the amount of clinical waste produced by the hospitals.

### Treatment and Disposal of clinical solid waste

Clinical waste collected daily by a private company or contractor to be delivered to the incineration plan for disposal

was paid by the hospital on a weight basis (USD 2.1 per kg of clinical solid waste). Special van (Fig.4b) is used to transport the waste from the central storage area to the designated disposal site an incineration plant, Melaka. There was an autoclave in the Microbiology laboratory used to sterilize microbiological lab waste (light blue colored plastic bag waste) before being transferred into yellow colored plastic bags. The radioactive waste generated in the hospital was collected by respective radioactive suppliers regulated by the Atomic, Energy Licensing Act 1984. In the case of pressurized container, it is often sent back to the original supplier.



(a)



(b)

**Fig. 4. Clinical solid waste collections for the disposal; (a). Transporting the clinical waste from internal storage area to centralized storage room following the internal transport route (b). Loading of clinical solid waste bins into the dedicated clinical waste van**

### Encouraging waste reduction

It has been increasingly recognized the recycling of waste materials is potential for minimization of the rising quantity of waste generated. Recycling of waste materials minimizes the

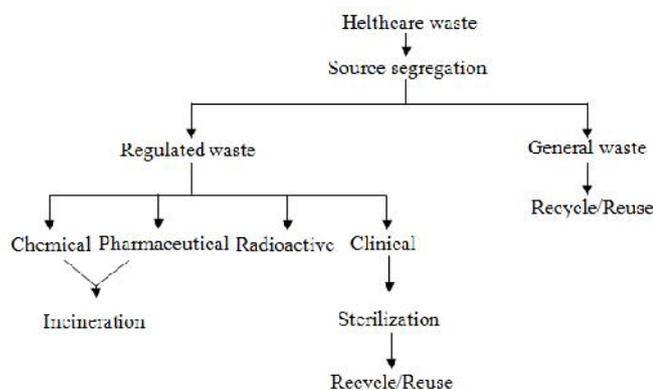
waste loads to landfill and incineration, which would save the treatment cost and reduce environmental pollution (Lee *et al.*, 2004; Tudor, 2007). Recently, healthcare facilities in the developing world have been conducting recycling the waste materials from the non-risk healthcare waste (i.e., general waste). There is still a lack of understanding to gain the optimal efforts on recycling the healthcare waste materials (Tudor, 2007). HLWE has started the 3R program (Recycling, Reuse and Reduction) of general solid waste in June, 2002 by setting up a Recycling Project Committee (RPC) with the objectives of the environmental protection and generating funds for the staff welfare. The RPC has 19 members, where each of the committee members plays an effective role in gaining success for the project. Several activities, i.e., recycling awareness campaign, exhibition, seminar, workshop, educational talk, were taken to highlight the importance of recycling program to the staff and public. It was evident from the hospital records that RPC has recycled 537,828.41 kg of wastes and sold the wastes worth of USD 98,143.58 by the December, 2011. The recyclables were segregated at generation source. Each ward and floor has a dedicated room for storing the recyclables. Old newspapers, books/magazines/ loose papers, cardboards, plastic bottles, drip bottles, glass bottles, tins/cans/cooking oil bottles, aluminum cans, plastic bags, wearable old cloths and even old car batteries were recycled by the RPC.

### Determination of the status of clinical solid waste management

The implementation of the successful clinical solid waste management is one of the most significant healthcare efforts into focus in Malaysia. The main objectives of an effective waste management practices are the reduction in the volume of waste and minimizing the disposal costs. It is observed that the HLWE has taken pertinent steps on safe management of clinical solid waste within the hospital in accordance with MOH guideline and regulation. Clinical solid waste and sharp objects are segregated at its generation are taken special care to avoid mixing with general waste by the healthcare staffs. Several educational programs like seminar and workshop were organized to build up the skills and knowledge of the healthcare staff on safe management of clinical waste. There was a regular monitoring by the Department of Infection Control on whether nurses and clinical staffs are complying with the legislation during waste segregation, storage and transportation. This allows HLWE to preserve a safe environment for staffs and patients within the hospital albeit requiring high financial investments for the clinical waste management. The clinical waste management cost about USD 2.1 for per kg of waste, paid to a private company for collection, transportation and disposal of clinical waste. The treatment cost was found higher than clinical waste management cost in Japan (USD 1.7 for per kg of infectious waste) (Miyazaki and Une, 2005). It can be apparent that the source segregation practices could protect the mixing of general waste with clinical solid waste, but the clinical solid waste management cost is still expensive due to the requirement of trained clinical staffs to handle the waste, regular monitoring and effective control from source segregation to final disposal. Moreover, the infectious risk

poses by clinical solid waste are still exist during segregation, collection and transportation. The self sustaining 3R program HLWE is benefiting the hospital to conduct effective source segregation practices of clinical solid waste by the clinical staffs. In addition, the RPC of the HLWE is earning money by selling the general waste materials, minimizing general solid waste to the municipal landfill site. The existing 3R program does not affect the clinical solid waste generation rate and its disposal cost of HLWE. A healthcare facility should take into consideration when choosing a waste treatment method of carrying out an environmental impact assessment both inside and outside of the hospital (Rutala, 1996). In addition to health risks to patients and personnel, consideration should be given to the serious negative impacts on human health and the environment of incinerating clinical solid waste.

Clinical solid waste contains enormous amount of recyclable and reusable materials (Marinkovi *et al.*, 2008; Lee *et al.*, 2004; Ruoyan *et al.*, 2010). Therefore, the present study suggests conducting the 3R program of clinical solid waste materials (i.e., infectious and sharp objects). To enable safer handling in order to continue the 3R program of clinical solid waste materials, the waste must be sterilized at its point of separation using a mobile device sterilization method (Marinkovi *et al.*, 2008; Sawalem *et al.*, 2009). The sterilization technology must be cost effective, easily implementable with low temperature and pressure so that it will not destroy heat sensitive materials. Infectious clinical solid waste materials and sharp objects would be free from infectious risk, therefore metallic, plastic and polymer material presence in infectious waste and all sharp materials could be recycled as secondary raw materials (Tudor, 2007).



**Fig. 5. Proposed healthcare waste management to HLWE, Penang Island, Malaysia**

The successful 3R program of clinical solid waste materials would benefit the hospital in many ways, such as reducing the clinical solid waste generation, minimize waste management cost, flexible regulatory guideline as well as to minimize the waste load goes to incineration plant. Besides, the hospital can earn money and provide a safer environment for patients, healthcare staffs and the public. The healthcare waste management practices in HLWE could further improve as presented in Fig.5. The pharmaceutical solid waste, which is presently segregating along with clinical waste in a yellow color Biohazard bag, must be segregated separately from the clinical solid waste.

## Conclusion

It was being observed that existing clinical solid waste management practices within the Hospitals Lam Wah Ee required training clinical staffs, effective control in all steps of waste management as well as high financial investments. Further, clinical solid waste was still disposed off through incineration despite the deadly health risks and environmental pollution. Therefore, the present study reveals a serious need to sterilize the clinical solid waste at its generation source to continue recycle-reuse program of clinical solid waste materials as an effective alternative of incinerating clinical solid waste. Which results in, the waste would not bear any infectious risk. Therefore, collection, segregation and recycling-reused program can be carried out with the ordinary clinical staffs. Accordingly, healthcare facilities can reduce the exposure of clinical solid waste, earn money by selling the recyclables, decrease labor cost as well as provide a safe environment for patients, public and healthcare staffs.

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