EXPLORING SUSTAINABLE HEALTHCARE WASTE MANAGEMENT IMPLEMENTATION IN TEACHING HOSPITALS IN MALAYSIA

Timothy Kurannen Baaki[1], Mohamad Rizal Baharum[1]*, Azlan Shah Ali[1], Mohd Hasni Jafa'ar[2]
[1]*Department of Building Surveying, Faculty of Built Environment, University of Malaya, 50603 Kuala Lumpur, MALAYSIA.*
[2]*Department of Community Health, Faculty of Medicine, Universiti Kebangsaan Medical Centre, 56000 Kuala Lumpur, MALAYSIA.*
*Corresponding author: mrizal@um.edu.my

Abstract
There are growing expectations for healthcare organizations to take active steps and introduce sustainable approaches to healthcare waste management (HCWM). This study investigated sustainable healthcare waste management (SHCWM) in two university teaching hospitals in Malaysia. The objectives of the study were to identify current practices and SHCWM initiatives as well as examine the training and knowledge of hospital staff on sustainable healthcare waste management. Following a questionnaire survey of 243 senior hospital staff, the study found that sustainable healthcare waste management initiatives were being implemented in the healthcare facilities (HCFs) surveyed. Descriptive statistics using frequency distributions and mean rank analysis were used to analyze data from the 243 respondents. The findings revealed that proper segregation and sorting, purchasing supplies that generate less hazardous waste, education/awareness about material reuse and recycling, purchasing environmentally friendly products, and encouraging material reuse and recycling through reward were the five initiatives perceived to be most implemented at the HCFs. The study also found that majority of the respondents received training and were highly knowledgeable about the health and environmental risks of HCW as well as SHCWM aspects such as waste minimization. The findings from this study provide an overview of SHCWM in particularly large teaching hospitals in Malaysia and suggests further research for a more comprehensive and wider understanding of SHCWM in HCFs in Malaysia.

Keywords: Healthcare waste, healthcare facilities, Malaysia, sustainable healthcare waste management, teaching hospitals.

Article history:
Submitted: 03/06/2019; Revised: 25/10/2019; Accepted: 19/11/2019; Online: 01/05/2020

INTRODUCTION

Waste continue to be a global problem and this is directly linked to the way society produces and consumes (Bogner *et al.*, 2007). The health and environmental risks posed by improper waste management have been well recognized (United Nations Environmental Protection, 2015). According to the Intergovernmental Panel on Climate Change (IPCC), methane emissions from landfills were responsible for about 3% of global greenhouse gas (GHG) emissions in 2010 (Stocker, *et at.,* 2013). There are claims that the potential contribution of better waste and resource management to climate change mitigation are huge. More than 50% of worldwide municipal solid waste as of 2012 was generated in Organisation for Economic Co-operation and Development (OECD) countries, and by that time most OECD waste was properly managed, with landfill gas being collected and either flared or utilized in energy recovery (World Bank, 2012). Some countries had already succeeded in diverting significant percentages of waste away from landfill disposal such as Germany, which credits 24% of its total savings in GHG emissions between 1990 and 2006 to solid waste management (UNEP, 2015).

Wastes from healthcare contribute to the growing problem of waste management most particularly from a public health perspective. Owing to the potential of sustainably managing wastes from healthcare facilities (HCFs), there are growing expectations that HCFs take active steps and introduce initiatives to curtail the impact of healthcare waste (Hutchins & White, 2009; Scally, 2009). Healthcare waste (HCW) is defined by the World Health Organization (WHO) as all wastes generated in the process of providing healthcare services (Chartier *et al.*, 2014). Numerous studies have been carried out on healthcare waste management practices in both the contexts of developing and developed nations (Abah, 2011; Abor & Bouwer, 2008; Akter, 2003; Bdour, Altrabsheh, Hadadin & Al-Shareif, 2007; Chaerul, Tanaka & Shekdar, 2008; Coker *et al.*, 2009; Da Silva *et al.*, 2005; Ali, Wang, & Nawaz, 2017; Baaki, Baharum & Akashah, 2017), however, considerable research on sustainble healthcare wase management particularly in developing countries is lacking. A study by Hossain *et al*.

(2011) involving 14 countries, mostly developing countries, found that only 3 out of the 14 investigated countries recycled parts of the waste generated from healthcare facilities. In Malaysia, there are very few studies on healthcare waste management generally. Existing studies have focused primarily on clinical/biomedical and or hazardous wastes (Ambali *et al.*, 2013; Chong, 2007; Razali & Ishak, 2010; Zaimastura, 2005). Although there is an integrated approach to HCWM in Malaysia (Ambali *et al.*, 2013), very little evidence exists on sustainable healthcare waste management. The aim of this study therefore is to explore sustainable healthcare waste management implementation in teaching hospitals in Malaysia. In particular, the study seeks to identify current practices and initiatives to sustainable healthcare waste management and examine their implementation as well as examine the training and knowledge of hospital staff on sustainable healthcare waste management.

LITERATURE REVIEW

Sustainable healthcare waste management

Sustainable waste management aims to address health and environmental impacts of waste through recovery, recycling, reuse of resources, and minimization of waste streams. The sustainable waste management hierarchy, shown in Figure 1 intends that more efforts be directed toward waste prevention with waste disposal considered as the last resort for wastes that inevitably must end up at waste disposal mechanisms (Hansen, Christopher & Verbuecheln, 2002). System conditions for sustainable waste management require that (Seadon, 2010):

- materials are not rapidly and increasingly extracted from the earth;
- wastes are not emitted by society at an increasing rate;
- wastes are not disposed of to the earth faster than they can break down through natural processes; and
- resources are used wisely and with waste minimization to meet the basic human needs globally.

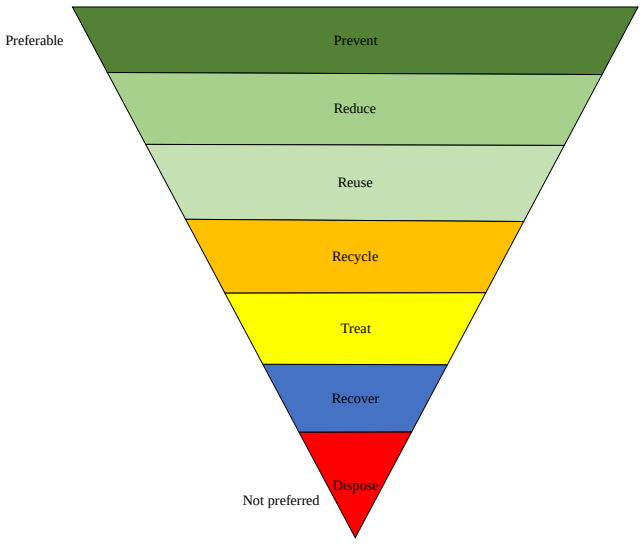


Figure 1: SWM hierarchy
Source: Adapted from Chartier *et al.* (2014)

In Malaysia, an initiative that has direct bearing on waste management is the voluntary commitment to cut down 40% of carbon emissions by the year 2020 (Government of Malaysia, 2011). Waste management could be seen as contributing hugely to the actualization of this goal as waste is the second largest contributor after energy to GHG emissions in Malaysia (Mohamad & Keng, 2013). Targets include a goal to recycle 22% of solid wastes by 2020 from the current 5% effort and the construction of more sanitary landfills throughout the country (Mohamad & Keng, 2013). Some of the sustainable waste management initiatives in Malaysia include recycling, which has a huge promising market but is rather populated by informal practices as a result of lack of legislation (Yahaya, 2012).

Cohen & Howard (2015), notes that healthcare waste management is a crucial aspect in any healthcare facility's sustainability initiative. Baaki (2014) contends that there is a general feeling that healthcare wastes once generated, are bound for disposal. This could be attributed to the pathogenic

properties of some categories of healthcare waste. The hazardous nature of healthcare waste is due to the presence of infectious agents, genotoxic or cytotoxic chemical composition, presence of toxic or hazardous chemicals or biologically aggressive pharmaceuticals, presence of radioactivity and presence of used sharps (Chartier *et al.*, 2014). Anyone in close proximity with hazardous healthcare waste is potentially at risk of exposure to a hazard, whether those working within healthcare facilities who generate hazardous waste, or those exposed to it as a consequence of careless actions. In Table 1 potential infections that could result from exposure to healthcare wastes are shown. The table shows a wide range of deadly infections, some of which have no absolute cure yet such as the acquired immunodeficiency syndrome (AIDS). The main groups of people at risk are (Chartier *et al.*, 2014):

- medical doctors, nurses, healthcare auxiliaries and hospital maintenance personnel
- patients in healthcare facilities or receiving home care
- visitors to healthcare facilities
- workers in support services, such as cleaners, people who work in laundries, porters
- workers transporting waste to a treatment or disposal facility
- workers in waste-management facilities (such as landfills or treatment plants), as well as informal recyclers (scavengers).

Table 1: Potential infections caused by exposure to healthcare wastes, causative organisms and transmission vehicles

Type of infection	**Examples of causative organisms**	**Transmission vehicles**
Gastroenteric infections	Enterobacteria, e.g. *Salmonella*, *Shigella* spp., *Vibrio cholerae*, *Clostridium difficile*, helminths	Feces and/or vomit
Respiratory infections	*Mycobacterium tuberculosis*, measles virus, *Streptococcus pneumoniae*, severe acute respiratory syndrome (SARS)	Inhaled secretions, saliva
Ocular infection	Herpes virus	Eye secretions
Genital infections	*Neisseria gonorrhoeae*, herpes virus	Genital secretions
Skin infections	*Streptococcus* spp.	Pus
Anthrax	*Bacillus anthracis*	Skin secretions
Meningitis	*Neisseria meningitidis*	Cerebrospinal fluid
Acquired immunodeficiency syndrome (AIDS)	Human immunodeficiency virus (HIV)	Blood, sexual secretions, body fluids
Hemorrhagic fevers	Junin, Lassa, Ebola and Marburg viruses	All bloody products and secretions
Septicemia	*Staphylococcus* spp.	Blood
Bacteremia	Coagulase-negative *Staphylococcus* spp. (including methicillian-resistant *S. aureus*), *Enterobacter*, *Enterococcus*, *Klebsiella* and *Streptococcus* spp.	Nasal secretion, skin contact
Candidemia	*Candida albicans*	Blood
Viral hepatitis A	Hepatitis A virus	Feces
Viral hepatitis B and C	Hepatitis B and C viruses	Blood and body fluids
Avian influenza	H5N1 virus	Blood, feces

Source: Chartier *et al*. (2014)

However, extensive disposal practices result in massive disposal costs (Nichols, Grose, Bennallick & Richardson, 2013). The National Health Service (NHS), a public health service establishment in the UK, for instance, incurred costs in the range of £73 million in 2005 disposing of wastes with much of the waste generated in the NHS considered potentially recyclable (Hutchins & White, 2009). According to the Royal College of Nursing (2011) an annual reduction of 20% in infectious waste generation could result in annual savings of about £8.84 million. The bulk of wastes generated from healthcare facilities have tremendous recycling potential (Hutchins & White, 2009;

Scally, 2009). Marmot (2010) suggests that recycling all paper, newspapers and cardboard produced by the NHS in England and Wales could result in the reduction of up to 42,000 tonnes of CO_2. Added to this potential is the dwindling capacities of landfills and incineration plants in many countries across the world (Scally, 2009). For instance, in Malaysia statistics show that in 2009 about 16,000 metric tons of healthcare waste was processed and disposed, a figure expected to rise to about 33,000 metric tons by 2020 with the current installed incinerators having a capacity to incinerate only up to 18,000 tons of wastes (Frost & Sullivan, 2010). The challenge of inadequate incinerators is one complicated by recent debate on the appropriateness of incineration as a sustainable method of healthcare waste disposal (Diaz, Savage, & Eggerth 2005; Wilburn, 2012). Scally (2009) argues that healthcare systems need to embrace a holistic approach to minimizing waste but also encourage commitment and innovation among healthcare professionals in individual specialties. As noted earlier, 75% to 90% of HCW is non-hazardous and similar to domestic-type wastes. Continuously, the healthcare waste management sector is being pressured to find ways to minimized waste and embrace recycling. According to Cohen & Howard (2015) inroads have been made toward a more sustainable healthcare waste management culture through new treatment technologies, reprocessing and recycling efforts. Statistics show that, the market for reprocessed medical devices alone is growing by 20% each year and will reach 2.5 billion devices by 2020 (Cohen & Howard, 2015). This is followed by claims made in some quarters that hospitals prevented more than 102,000 tons of waste through recycling projects in 2013, saving $28 million (Practice Greenhealth, 2014).

In 2007, the World Health Organization published what it called “WHO core principles” for safe and sustainable management of healthcare waste. The WHO core principles stipulate that, all associated with financing and supporting healthcare activities should provide for cost of managing HCW. Also, manufacturers of healthcare products should bear in mind the concerns of healthcare waste management while developing and marketing their products. In keeping with these core principles, WHO recommends the following actions for governments, donors and partners, non-governmental organizations (NGOs), private sector, all other institutions and organizations involved with the provision of healthcare (WHO, 2007):

- Governments should appropriate adequate funds for the establishment and maintenance of sound healthcare waste management systems; ask partners and donors to contribute toward the management of wastes associated with their interventions; and implement, coordinate and monitor sound healthcare waste management systems.
- Donors and partners who provide health programs and interventions should allocate funds to cover sound healthcare waste management systems.
- NGOs should promote and undertake programs aimed at achieving sound healthcare waste management.
- The private sector and producers should assume responsibility for the sound management of healthcare waste management, including the design and packaging of products.
- All concerned institutions and organizations should promote sound healthcare waste management; develop initiatives to minimize volume and toxicity of the waste they generate and those associated with their products; and ensure that global health strategies and programs accommodate sound healthcare waste management.

METHODS

This study utilized a quantitative approach with the use of a questionnaire survey of 243 senior management staff responsible for decision- and policymaking at department level at two large hospitals located in two of Malaysia’s most urbanized cities. Both HCFs, referred to in this study as University Teaching Hospital (UTH) A and University Teaching Hospital (UTH) B are university teaching hospitals. They provide tertiary healthcare services with a combined bed capacity of over 2600 beds and a combined patient traffic of about 1.6 million patients per annum. Although the hospitals provide the same care services, careful analysis of the characteristics indicate that UTH A appears to be a larger facility and do experience more patient traffic.

Data collection

Questionnaire survey

The aim of the questionnaire survey was to identify current waste management practices, sustainable healthcare waste management initiatives currently implemented as well as examine the training and knowledge of hospital staff on sustainable healthcare waste management. The nature of the characteristics of the targeted population for the study required the questionnaire originally designed in English Language to be translated into the Malay Language (used both in official and unofficial

settings in Malaysia). As such, it was also mandatory to provide a Malay version of the data collection instrument during the ethics application process. The questionnaire consisted of two (2) main sections, and a total of 8 questions. The first section covered demographic characteristics of the respondents. The second section covered waste management practices and the third section covered SHCWM practices and initiatives. The measurement used in the third section of the questionnaire was generally based on a 5-point Likert scale. The 5-point Likert scale has been used widely in survey research, including research on waste management subjects (Baharum, 2011). The questionnaire comprised primarily of closed-ended questions requiring the respondents to tick the appropriate boxes. Stratified random sampling was used for the questionnaire survey. de Vries (1986) notes that, where a population shows or consists of different strata, precise information (i.e. a smaller variance) will be obtained if a stratified random sampling technique is used instead of simple random sampling. The first stage stratified the sample size across the two case study hospitals while the second stratification was among the group of respondents categorized into three main groups: (a) doctors, physicians, medical assistants; (b) matrons/nurses; and (c) administrative staff (those holding purely administrative positions). These were the staff adjudged to be responsible for decision- and policymaking at department level and were directly or indirectly involved in the planning and implementation of waste management activities at the HCFs. A total of 130 questionnaires were distributed to doctors, physicians, medical assistants, pharmacists, lab scientists; 156 to matrons/senior nurses; and 114 to administrative staff. Out of the 400 distributed questionnaires, 243 returned questionnaires were deemed valid for further analysis. The Statistical Packages for Social Sciences (SPSS) Version 25 was used to analyze the survey responses. Descriptive statistical analysis techniques such as frequency distribution and mean ranking were used to analyze the questionnaire data.

RESULTS AND DISCUSSION

Characteristics of respondents

As shown in Table 2, 61.3% of the respondents were from UTH B while 38.7% were from UTH A. Regarding designation/job title, majority of the respondents were matrons/senior nurses (51.9%), followed by administrative staff (26.8%), and then doctors (18.9%). Lab scientists and pharmacists made up 1.2% each of the respondents. This indicates that the respondent pool represents a diverse and relatively appropriate representation of the population. About two-thirds (65.8%) of the respondents had been working at their respective HCFs for between 6 to more than 16 years, while 34.2% had been working at their respective HCFs for 5 years or less. About 70.8% of the respondents had been working in their respective departments for between 2 to more than 5 years, while 29.2% had been working at their respective HCFs for 1 year or less. This shows that, the respondents have been working at their respective HCFs and departments/units long enough to be knowledgeable about major activities at the HCFs, thus their responses can be considered to be reliable and thus provide the study with valuable information.

Types of waste generated by the respondents

The respondents were asked to indicate the nature of wastes they generated based on the HCW classification by the World Health Organization. The results in Figure 2 show that 94.2% of respondents reported they generated paper waste, 84.4% indicated the wastes they generated included needles, and 77.8% indicated the wastes they generated included packaging materials. Only 23% reported the waste they generated included aerosol cans, while 25.9% reported the waste they generate included solid, liquid, gaseous waste contaminated with radionuclides, and 28% indicated the wastes they generated included organs. This means that, wastes in the categories of general waste and sharp waste were the most common waste items from the HCFs as attested to by the respondents. Similar nature of waste generation has been reported in previous studies in both private and government hospitals in Malaysia (Nazli, Subramaniam, Karuppannan & Omar, 2014; Tiong, Latiff & Karuppannan, 2012).

Waste segregation

In Figure 3, the segregation practice by the respondents is shown. It can be seen from Figure 3 that, although majority of the respondents disposed of the wastes they generated in the appropriate bin/container, a percentage of the respondents (between 1.2% for general waste and 11.5% for wastes with high metal content) segregated the wastes they generated into the wrong bin/container. Segregation minimizes the volume of certain waste types in the medical waste stream and is the key to choosing treatment and disposal options. This study found that waste segregation was reasonably achieved, although the practice of waste segregation was not 100% adhered to. Although

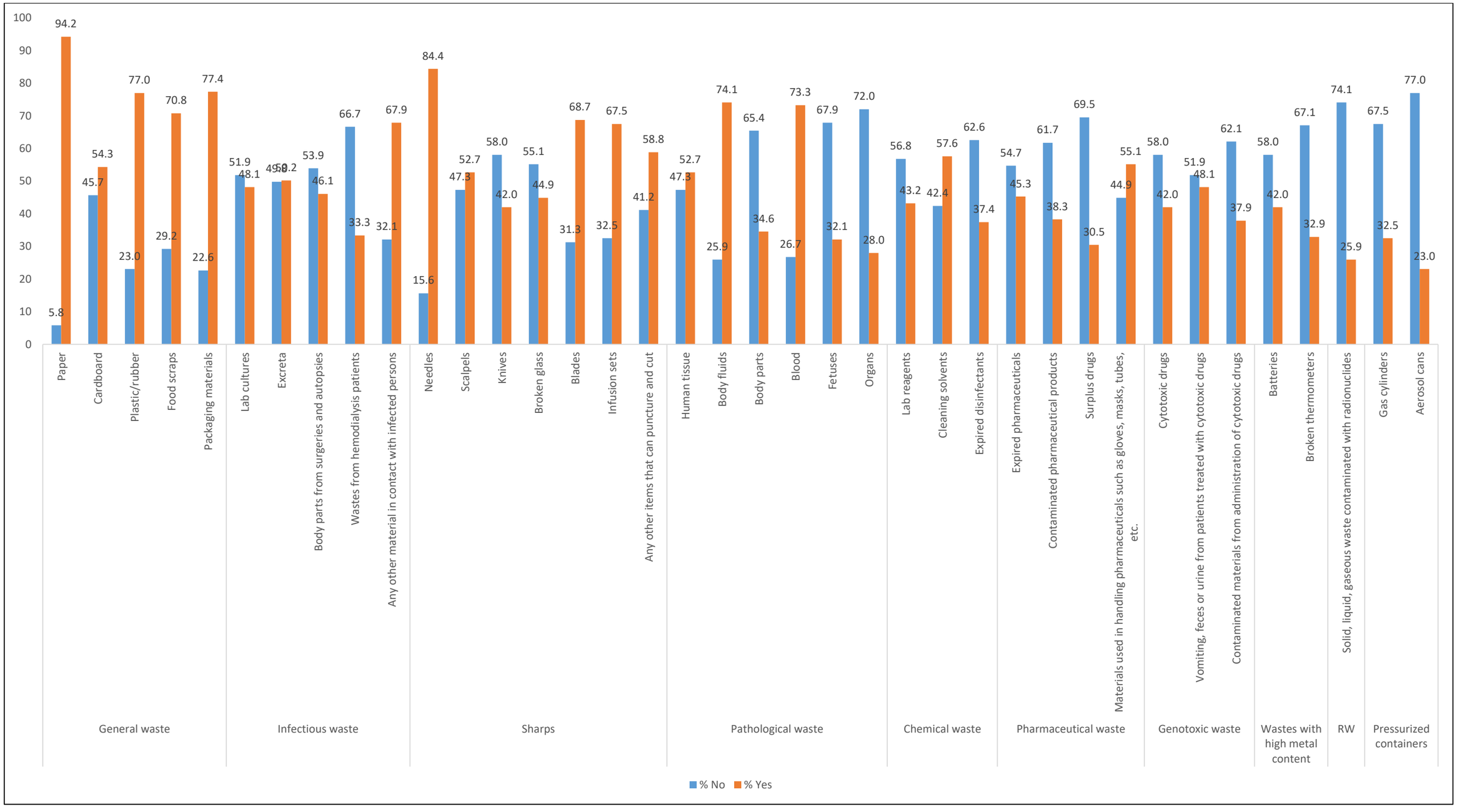
commendable segregation was practiced, general wastes still ended up in clinical waste bins. These results reflect previous findings by Hamadan *et al*. (2012), Razali & Ishak (2010), and Zaimastura (2005) who reported segregation was reasonably practiced in both private and government hospitals in Malaysia.

Table 2: Demographic Characteristics

Item	Description	Frequency	Percentage	Cumulative percentage
Name of HCF	UTH A	94	38.7	38.7
	UTH B	149	61.3	100
	Total	243	100	
Period of working in current HCF	5 years or less	83	34.2	34.2
	6 - 10 years	44	18.1	52.3
	11 - 15 years	43	17.7	70
	16 years and above	73	30	100
	Total	243	100	
Years of working in current department	1 year or less	67	29.2	29.2
	2 - 3 years	46	20.1	49.3
	4 - 5 years	19	8.3	57.6
	6 years and above	97	42.4	100.0
	Total	229	100	
Designation	Doctor	46	18.9	18.9
	Matron/senior nurse	126	51.9	70.8
	Lab scientist	3	1.2	72
	Pharmacist	3	1.2	73.2
	Admin officer	65	26.8	100
	Total	243	100	

Waste collection and use of Personnel Protective Equipment (PPE)

To gather information about the frequency of waste collection, the respondents were asked to indicate the number of times each category of waste was collected from their departments. Figure 4 shows that the waste categories that were collected mostly 5 times per day were sharps waste (22.6%), followed by general waste (22.2%), and then pressurized containers (16.1%) and radioactive waste (16.1%). The waste categories mostly collected 4 times per day were general waste (8.6%), followed by infectious waste (5.8%), and then sharps waste (4.5%). The wastes categories mostly collected 3 times per day were general waste (28%), followed by infectious waste (8.6%), and then pharmaceutical waste (6.6%). The waste categories mostly collected 2 times per day were infectious waste (32.1%), followed by general waste (31.7%), and then sharp waste (28.4%). The waste categories mostly collected once per day were sharps waste (20.2%), followed by infectious waste (20.2%), and then pathological waste (14.8%). The results show that the waste collection frequency ranged from once a day to 5 times per day, with waste collection 2 times per day having the highest overall collection frequency for infectious waste, general waste and sharps waste. In Figure 5, the results show that 81% of the respondents reported that waste handling personnel wore PPE when collecting the waste generated from their departments. As high as the number is, it indicates that 19% of waste collection and handling personnel did not adhere to the appropriate use of PPE. This percentage includes those collecting wastes classified as clinical waste from areas such as treatment wards and operation theaters (OT). The results compare with findings from Omar, Nazli, & Karuppannan (2012), and Razali & Ishak (2010) who reported that, wastes were collected daily and waste collection personnel wore appropriate PPE such as gloves, face masks, aprons, and safety boots. While it appears that overwhelming majority of waste handling personnel abided by PPE use, the nature of HCW and the health risks associated with its handling requires strict adherence to PPE use especially for those handling clinical wastes. According to Chartier *et al*., (2014), appropriate PPE include face masks, protective clothing such as overalls, industrial apron; puncture- and water-proof boots; heavy duty gloves; protective eyewear; helmets, with or without visors. Depending on the nature of risk associated with the type of waste being handled by waste handling personnel or type of operation, the nature of PPE may vary, however, Chartier *et al*., (2014) further points out that industrial gloves; industrial aprons; overalls and industrial boots are mandatory, meaning this is the minimum PPE gear that must be worn by waste handling personnel collecting or handling the lowest risk waste type.



RW = Radioactive waste

Figure 2: Types of waste generated according to WHO classifications

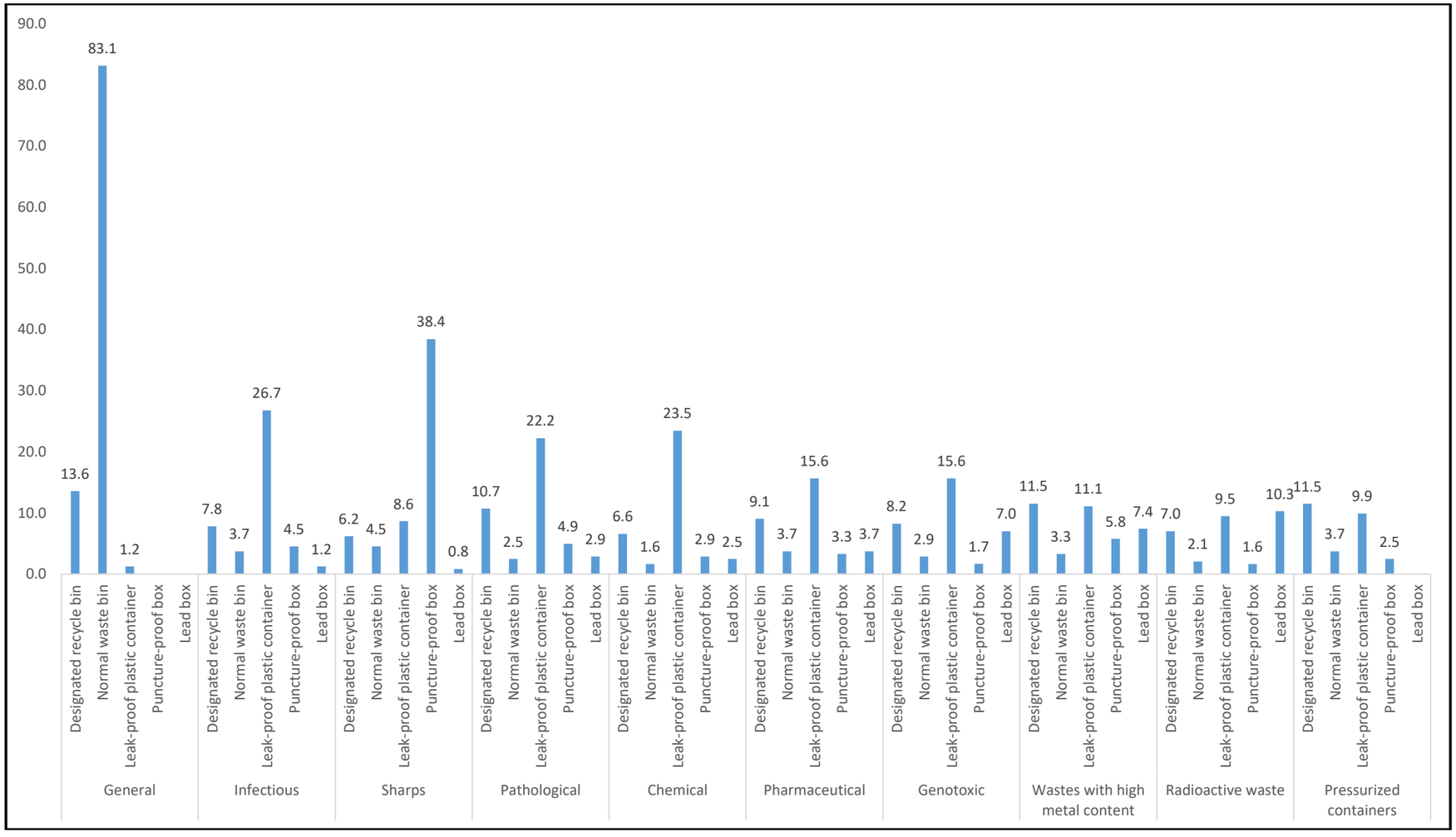


Figure 3: Waste segregation practice

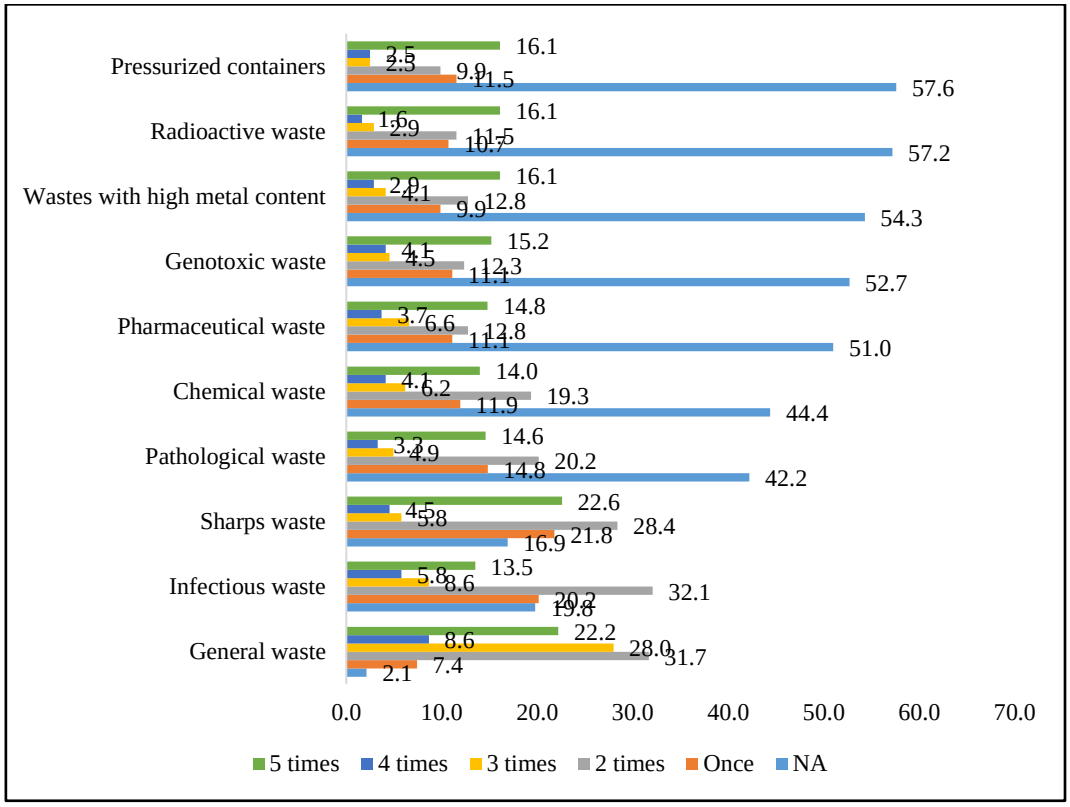


Figure 4: Waste collection

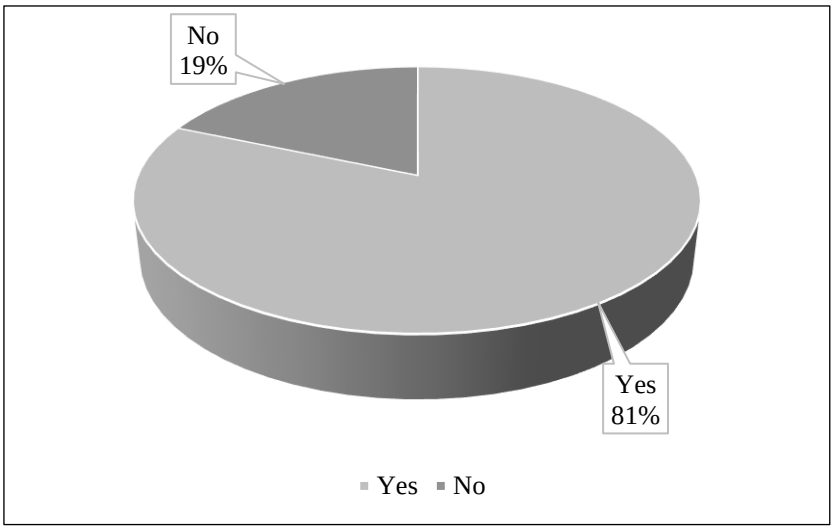


Figure 5: PPE use by waste handling personnel

Initiatives for sustainable HCWM implemented at the HCFs

To identify the nature of sustainable healthcare waste management initiatives implemented at the HCFs, the respondents were asked to rank a set of initiatives for sustainable healthcare waste management according to their perception of the extent to which the initiatives were implemented at their HCFs. Table 3 shows that proper segregation and sorting (mean=3.56; SD=0.698), purchasing supplies that generate less hazardous waste (mean=3.56; SD=0.743), education/awareness about material reuse and recycling (mean=3.55; SD=0.777), purchasing environmentally friendly products (mean=3.54; SD=0.0.734), and encouraging material reuse and recycling through reward (mean=3.53; SD=0.804) were the five highest ranked implemented initiatives. Selection of methods or supplies that generate less waste (mean=3.39; SD=0.721), purchasing recyclable products (mean=3.40;

SD=0.834), and preference for purchasing reusable items over disposable ones (mean=3.42; SD=0.879) were the least ranked implemented initiatives. Incineration with air pollution control (APC) (mean=1; SD=0.000), sanitary landfill (mean=1) were not implemented at all, suggesting the lack of onsite treatment and disposal facilities. The findings reveal that active measures are being implemented at these HCFs to achieve sustainable healthcare waste management. Several studies have reported the potential of implementing sustainable healthcare waste management (Hutchins & White, 2009; Scally, 2009), and the benefits that are associated with sustainable waste management practices in HCFs (Marmot, 2010; Royal College of Nursing, 2011). This is particularly true for large HCFs such as teaching hospitals who generate enormous amounts of wastes (DOE, 2005, 2009). As reported by Practice Greenhealth (2014), recycling initiatives in certain hospitals led to the prevention of more than 102,000 tons of wastes in 2013. Another study by Nichols *et al.* (2013) reported recycling practices in NHS hospitals in the UK, however, the study suggesting poor recycling behavior with the observed respondents reporting high intention to recycle but their actual practice showing otherwise.

Table 3: Rank analysis of initiatives for sustainable HCWM implemented at the HCFs, ordered according to descending means

Item	Mean (*N*=243)	Std. Deviation	Rank
Proper segregation and sorting	3.56	0.698	1
Purchasing supplies that generate less hazardous waste (e.g., purchase of non-mercury thermometers, etc.)	3.56	0.743	2
Education/awareness about material reuse and recycling	3.55	0.777	3
Purchasing environmentally friendly products	3.54	0.734	4
Encourage material reuse and recycling through reward	3.53	0.804	5
Recycling	3.51	0.789	6
Prudent use of materials	3.49	0.706	7
Sourcing suppliers within close proximity	3.47	0.676	8
Reuse of materials	3.46	0.819	9
Purchasing of reprocessed sing use devices (SUDs)	3.43	0.857	10
Environmentally friendly treatment options such as microwaving, autoclaving, etc.	3.43	0.832	11
Preference for purchasing reusable items over disposable ones	3.42	0.879	12
Purchasing recyclable products	3.40	0.834	13
Selection of methods or supplies that generate less waste	3.39	0.721	14
Sanitary landfills	1	0.000	15
Incineration with air pollution control (APC)	1	0.000	16

Training and knowledge on sustainable healthcare waste management

The respondents were asked to indicate how often they receive training at their healthcare facility on aspects of sustainable healthcare waste management which included health and environment risks of HCW; waste prevention, minimization, segregation, and waste handling. This question was specifically related to formal training exercises on HCWM administered or conducted by the HCF. In Figure 6, the results show that training on HCWM was conducted at the HCFs up to four (4) times a year. Majority of the respondents (46.1%) reported that they received training on health and environmental risks of HCW once a year, and 41.2% indicated they received training on waste prevention, minimization segregation and handling once a year. In total, about 71% indicated that they have received training on health and environmental risks of healthcare waste at their healthcare facility while about 72% indicated they have received training on waste prevention, minimization, segregation and handling. This shows that periodic trainings were carried out at the observed HCFs. These training practices reflect recommendations from the World Health Organization that training be done on a routine basis, at least annually, with the training curriculum covering areas such the potential hazards, injuries, infection prevention and use of PPE (Chartier *et al*., 2014). However, despite periodic trainings, it can be seen from the results that not all of the surveyed respondents

received training on HCWM. About 29% of the respondents indicated they did not receive HCWM training from their HCFs. While there was no evidence of making participation in training exercises mandatory for staff, several other reasons could be responsible for some of the respondents reporting non-participation in training on HCWM.

The respondents were asked to indicate their level of knowledge about aspects of sustainable healthcare waste management which included health and environment risks of HCW; waste prevention and minimization, segregation (color coding/type of container), and waste handling. Figure 7 shows that regarding health and environmental risks of HCW, majority of the respondents expressed 'high' knowledge (76%), 14.9% had 'moderate' knowledge, and 1.2% had 'very high' knowledge. Regarding waste prevention and minimization, 78.1% expressed 'high' knowledge, while 14.5% expressed 'moderate' knowledge, and 0.4% expressed 'very high' knowledge. Regarding segregation, majority of the respondents (73.7%) indicated they had 'high' knowledge on segregation (color coding/type of container), 11.9% expressed they had 'moderate' knowledge, and 2.9% indicated they had 'very high' knowledge. About waste handling, majority of the respondents (80.2%) indicated they had 'high' knowledge, while 13.6% indicated they had 'moderate' knowledge, and 1.2% indicated they had 'very high' knowledge. Less than 2% of the indicated they had 'very low' knowledge on all four parameters health and environment risks of HCW (0.4%), waste prevention and minimization (0.8%), segregation (color coding/type of container) (1.6%), and waste handling (0.8%). In total, 100% of the respondents indicated they had knowledge on healthcare waste management. Out of this percentage, about 77% had 'high' to 'very high' knowledge on health and environmental risks of HCW, about 78% had 'high' to 'very high' knowledge on waste prevention and minimization, while about 77% had 'high' to 'very high' knowledge on segregation, and 81% had 'high' to 'very high' knowledge on waste handling. These results are similar to findings by Nazli, Subramaniam, Karuppannan, & Omar (2014) who found that majority of the surveyed respondents indicated high level of knowledge on HCWM.

Training and education is often cited as an important facet of healthcare waste management in HCFs (Mathur, Dwivedi, Hassan & Misra, 2011; Ozder *et al*., 2013). It is imperative to be aware of the risks associated with healthcare waste. This can only be achieved through training programs that include awareness campaigns such as instructive posters and signages and regular training engagements that do not only inform HCWM personnel and other stakeholders to the risks of healthcare waste but also inform them of relevant regulations guiding its management as well as best practice guidelines. The nature of wastes generated at HCFs require continuous training on the types of management approaches to dealing with such wastes. Adequate training at the HCF level is necessary, where all parties involved such as staff, patients, relatives of patients are made to understand the risks associated with HCW and the appropriate management approaches that must be adopted to safely as well as sustainably manage these wastes. Particularly for waste handling personnel, inadequate training makes them more vulnerable to risk of infection. Not having a good understanding of the full spectrum of risks associated with healthcare wastes can lead to a casual disposition among both waste generation sources and waste management personnel resulting in an improper HCWM situation that have negative health and environmental consequences (Baaki *et al*., 2017).

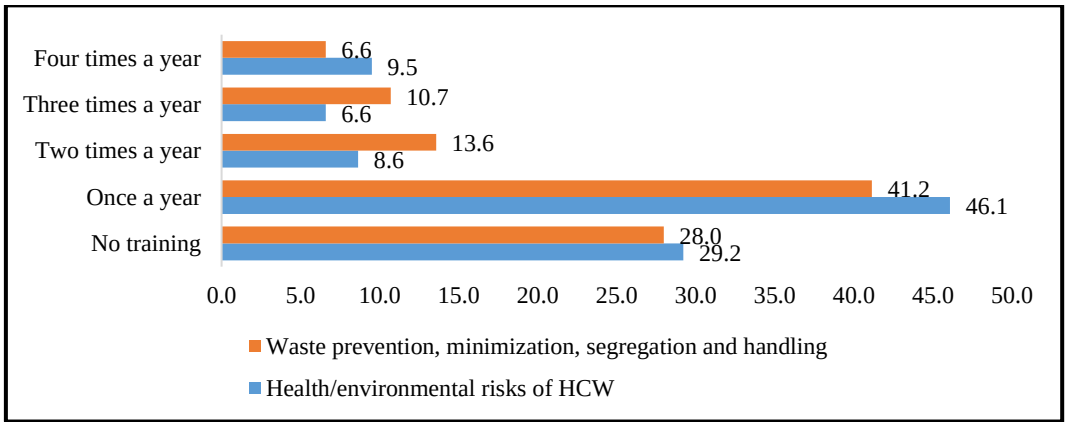


Figure 6: Training on aspects of sustainable healthcare waste management

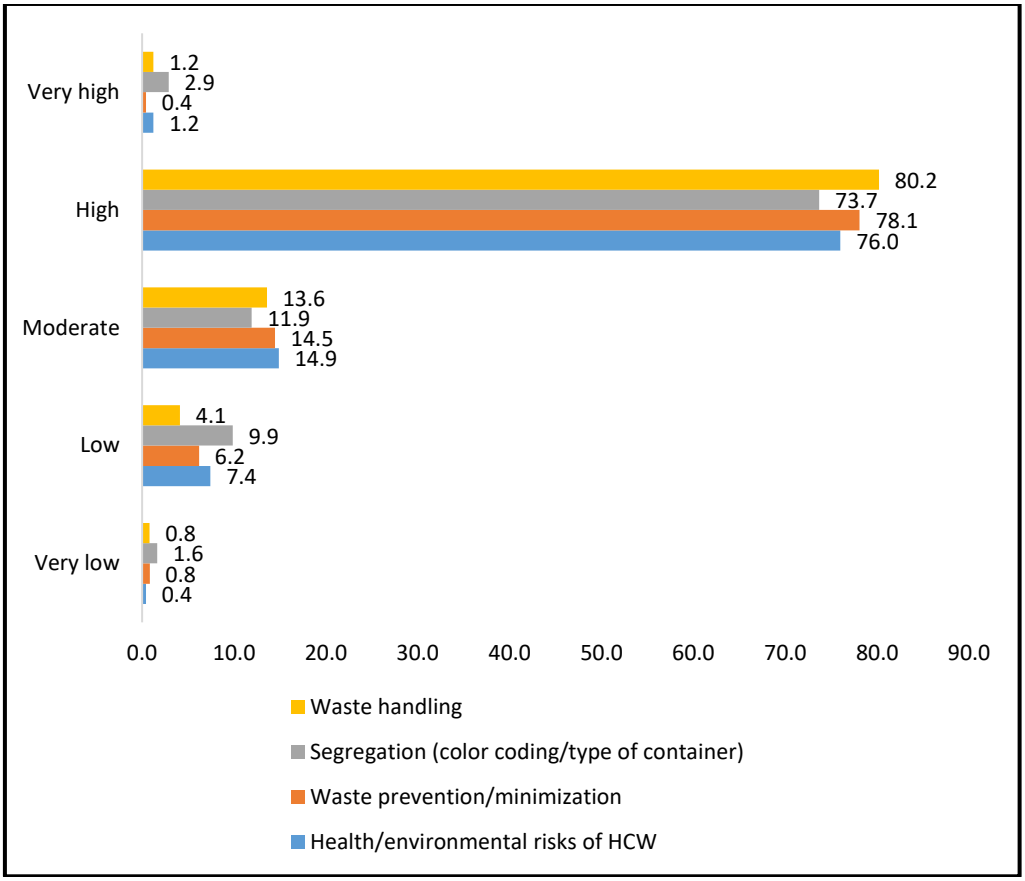


Figure 7: Level of knowledge about aspects of sustainable healthcare waste management

CONCLUSIONS

With majority of HCW similar to domestic-type waste, it is becoming increasing imperative that hospitals find ways and devise initiatives to sustainably manage their wastes. While the challenges of balancing patient and staff safety with sustainable waste management approaches exist, appropriate documentation of waste generation and proper segregation could open vast opportunities for instituting initiatives towards HCW minimization, recycling, and sustainable treatment and disposal. The findings from this study revealed sustainable HCWM attempts in two university teaching hospitals and identified proper segregation and sorting, purchasing supplies that generate less hazardous waste, education/awareness about material reuse and recycling, purchasing environmentally friendly products, and encouraging material reuse and recycling through reward were as the five initiatives perceived to be most implemented. The study also found that majority of the respondents received training and were highly knowledgeable about the health and environmental risks of HCW as well as sustainable healthcare waste management aspects such as waste minimization. Training and education on both the risks, hazards, consequences and potential benefits of proper and sustainable HCW management in hospitals is important so as to elevate the awareness of all those involved with the generation, management and disposal of HCW. While only two HCFs have been considered in this study, the study provides a first and exploratory look into sustainable healthcare waste management, particularly in large HCFs in Malaysia. Further research is therefore needed to reflect a wider and more in-depth understanding of SHCWM in various hospital types in Malaysia. Further research could also focus on identifying the benefits of SHCWM and linking these benefits to the core objectives of hospital organizations.

Acknowledgment

This work was supported by University of Malaya Grant (Grant No: RF001F-2018). Special thanks to Mr. Zolkepli and admin staff at the observed hospitals who gave unrelenting assistance throughout the data collection process for this study.

Ethical consideration

The conduct of this research was approved by the University of Malaya Research Ethics Committee (Non-Medical Research) (UMREC) as well as the respective research ethics committees from the participating hospitals with ethics approval numbers UM.TNC2/UMREC-167, MREC ID NO: 2017811-5488, and PPI/111/8/JEP-2017-522 for University of Malaya Research Ethics Committee, UTH A Research Ethics Committee, and UTH B Research Ethics Committee respectively.

References

Abor, P.A., & Bouwer, A. (2008). Medical Waste Management Practices in a Southern African Hospital. *International Journal of Health Care Quality Assurance, 21*(4), 356-364.

Abah, S. O., & Ohimain, E. I. (2011). Healthcare waste management in Nigeria: A case study. *Public Health and Epidemiology, 3*(3), 99-110.

Akter, N., & Trankler, J. (2003). An Analysis of Possible Scenarios of Medical Waste Mangement in Bangladesh. *Management of Environmental Quality, 14*(2), 242-225.

Ali, M, Wang, W, & Chaudhry, N (2017) Assessment of hospital waste management in a major city of Pakistan. *International Journal of Environment and Waste Management*, *19*(2), 97-104

Ambali, A.R., & Bakar, A.N. (2012, 3-4 Dec. 2012). *Medical waste management in Malaysia: Policies, strategies and issues.* Paper presented at the Humanities, Science and Engineering (CHUSER), 2012 IEEE Colloquium.

Ambali, A. R., Bakar, S. N., & Merican, F. M. (2013). Environmental policy in Malaysia: biomedical Waste, strategies and issues. *Journal of Administrative Science, 1*(10).

Baaki, T. K. (2014). *An Evaluation of Medical Waste Management Practices in Healthcare Facilties in Benue State, Nigeria.* (Unpublished master's thesis), University of Malaya, Kuala Lumpur, Malaysia.

Baaki, T. K., Baharum, M. R., & Akashah, F. W. (2017). Critical Success Factors of Medical Waste Management Implementation in Healthcare Facilities in Nigeria: A Case Study. *Journal of Design and Built Environment, 17*(1), 18-35.

Baharum, M. R. (2011). *Recycling initiatives in the UK shopping centres, factors critical to success* (Unpublished PhD thesis), Liverpool John Moores University, Liverpool, United Kingdom.

Bdour, A., Altrabsheh, B., Hadadin, N., & Al-Shareif, M. (2007). Assessment of medical wastes management practice: A case study of the northern part of Jordan. *Waste Management, 27*(6), 746-759. doi:http://dx.doi.org/10.1016/j.wasman.2006.03.004

Bogner, J., Ahmed, M. A., Diaz, C., Faaij, A., Gao, Q., Hashimoto, S., ... & Zhang, T. (2007). Waste management, in climate change 2007: mitigation. *Contribution of working group III to the fourth assessment report of the intergovernmental panel on climate change, Cambridge University Press, Cambridge, United Kingdom and New York, USA*.

Chaerul, M., Tanaka, M., & Shekdar, A. V. (2008). A system dynamics approach for hospital waste management. *Waste Management, 28*(2), 442-449. doi:http://dx.doi.org/10.1016/j.wasman.2007.01.007

Chong, K. F. (2007). *Clinical waste management and disposal: a case study of Hospital Tengku Ampuan Rahimah, Klang Selangor.* (Unpublished thesis), Universiti Teknologi Malaysia.

Cohen, G., & Howard, J. (2015). Seaweed on the Beach: Reducing the Burden of Healthcare Waste. *EXPLORE: The Journal of Science and Healing, 11*(4), 331-332. doi:http://dx.doi.org/10.1016/j.explore.2015.04.014

Coker, A., Sangodoyin, A., Sridhar, M., Booth, C., Olomolaiye, P., & Hammond, F. (2009). Medical waste management in Ibadan, Nigeria: Obstacles and prospects. *Waste Management, 29*(2), 804-811. doi:http://dx.doi.org/10.1016/j.wasman.2008.06.040

de Vries, P. G. (1986). Stratified random sampling. In *Sampling theory for forest inventory* (pp. 31-55). Springer, Berlin, Heidelberg.

Diaz, L. F., Savage, G. M., & Eggerth, L. L. (2005). Alternatives for the treatment and disposal of healthcare wastes in developing countries. *Waste Management, 25*(6), 626-637. doi:http://dx.doi.org/10.1016/j.wasman.2005.01.005

DOE. (2005). Clinical wastes in Malaysia: Guidelines on the handling and management

DOE. (2009). *Guidelines on the Handliing and Management of Healthcare Waste in Malaysia*. Retrieved from http://www.doe.gov.my/portalv1/wp-content/uploads/2010/07/anagement_Of_Clinical_Wastes_In_Malaysia__2__0.pdf.

Frost & Sullivan. (2010). Medical waste finds growth in Malaysia's robust healthcare system. Retrieved from http://www.frost.com/prod/servlet/press-release.pag?docid=209446374

Hamadan, N., Sapri, M., Mohammed, A. H., Awang, M., Rahman, M. S. A., Rosli, N. W., & Lah, N. M. I. N. (2012). The Implementation of Clinical Waste Handling in Hospital Sultanah Aminah Johor Bahru (HSAJB). *Procedia - Social and Behavioral Sciences, 65*, 802-807. doi:http://dx.doi.org/10.1016/j.sbspro.2012.11.202

Hansen, W., Christopher, M., & Verbuecheln, M. (2002). EU waste policy and challenges for regional and local authorities. *Ecological Institute for International and European Environmental Policy: Berlin, Germany*.

Hutchins, D. C., & White, S. M. (2009). Coming round to recycling. *BMJ, 338*, b609. doi:10.1136/bmj.b609

Marmot, M. (2010). *Fair Society, Healthy Lives: Strategic Review of Health Inequalities in England Post 2010*. Retrieved from http://www.parliament.uk/documents/fair-society-healthy-lives-full-report.pdf

Mathur, V., Dwivedi, S., Hassan, M., & Misra, R. (2011). Knowledge, attitude, and practices about biomedical waste management among healthcare personnel: A cross-sectional study. *Indian journal of community medicine: official publication of Indian Association of Preventive & Social Medicine, 36*(2), 143.

Nazli, S. N., Subramaniam, A., Karuppannan, L., & Omar, D. (2014). Knowledge and awareness of clinical waste management among medical practitioners in hospital Batu Pahat, Johor. *International Journal of Innovation, Management and Technology, 5*(2), 139.

Nichols, A., Grose, J., Bennallick, M., & Richardson, J. (2013). Sustainable healthcare waste management: a qualitative investigation of its feasibility within a county in the south west of England. *Journal of Infection Prevention, 14*(2), 60-64.

Ozder, A., Teker, B., Eker, H. H., Altındis, S., Kocaakman, M., & Karabay, O. (2013). Medical waste management training for healthcare managers-a necessity? *Journal of environmental health science and engineering, 11*(1), 20.

Omar, D., Nazli, S. N., & Karuppannan, S. A. L. (2012). Clinical Waste Management in District Hospitals of Tumpat, Batu Pahat and Taiping. *Procedia - Social and Behavioral Sciences, 68*, 134-145. doi:http://dx.doi.org/10.1016/j.sbspro.2012.12.213

Practice Greenhealth. (2014). *Sustainability benchmark report*. Retrieved from https://practicegreenhealth.org/about/press/press-releases/practice-greenhealth-announces-new-2014-sustainability-benchmark-report

Razali, S. S., & Ishak, M. B. (2010). Clinical Waste Handling and Obstacles in Malaysia. *Journal of Urban and Environmental Engineering, 4*(2), 47-54. doi:10.4090/juee.2010.v4n2.047054

Royal College of Nursing, R. (2011). *Freedom of Information Report on Waste Management.* Retrieved from https://www.rcn.org.uk/professional-development/publications/pub-004108

Scally, G. (2009). Environmental waste in health care. *BMJ, 338*.

Seadon, J. K. (2010). Sustainable waste management systems. *Journal of Cleaner Production, 18*(16-17), 1639-1651.

Stocker, T. F., Qin, D., Plattner, G. K., Tignor, M., Allen, S. K., Boschung, J., ... & Midgley, P. M. (2013) Climate Change 2013: The Physical Science Basis: Working Group I Contribution to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Geneva: Switzerland

Tiong, C. S., Latiff, P. A., & Karuppannan, S. a. l. (2012, April 13-15). *Medical waste management in private medical clinics, Taiping, Perak*. Paper presented at the International Conference on Ecological, Environmental and Bio-Science (ICEEBS'2012), Pattaya.

UNEP. (2015). *Global waste management outlook*: UNEP.

WHO. (2007). *WHO core principles for achieving sustainable management of health-care waste*. Geneva: WHO

Wilburn, S. (2012). *Overview of wastes from health care activities*. Paper presented at the UNEP IETC, Osaka, Japan. http://www.unep.org/ietc/Portals/136/Events/HealthcareWasteWorkshop-July2012/1-Wilburn.ppt

World Bank. (2012). What a waste: A Global Review of Solid Waste Management. Retrieved from http://documents.worldbank.org/curated/en/302341468126264791/pdf/68135-REVISED-What-a-Waste-2012-Final-updated.pdf

Zaimastura, I. (2005). *Management and disposal of clinical waste: a case study of Hospital Universiti Kebangsaan Malaysia.* (Unpublished bachelor thesis), Universiti Teknologi Malaysia.