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## **Associated factors of medical waste management practices in developing countries: a review**

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### **Abstract:**

The heterogeneous composition of waste from healthcare facilities has historically been a significant challenge with management efforts concentrating primarily on treatment and disposal solutions. This has left a legacy of issues with the management of this type of waste, especially for developing nations. This paper has examined the associated factors of medical waste management (MWM) practices in healthcare facilities in developing nations. Medical waste (MW) definitions have been examined, and factors associated with its management, from regulation and policy formulation to disposal, have been identified through desk research of existing studies. This paper found that in some countries where MWM legislation and policies exist, some are either poorly formulated or are an offshoot of general environmental waste

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management regulations. More specifically for developing countries, this study found that training, segregation, handling and disposal practices and implementation of MWM programmes were often at a poor standard. Poor regulatory frameworks, poor risk awareness and training, poor financing, influence of social factors such as cultural norms, poor infrastructure and technological advancement were some of the factors identified as key issues. This paper viewed the challenges of MWM practices in developing countries to be much more of a management issue than a technological issue and has identified advanced routine management approaches within an integrated sustainable MWM framework as a tool to drive improvements in MWM programmes.

**Keywords:** developing countries, healthcare facilities, medical waste, sustainable medical waste management, waste management practices

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## **1 Introduction**

The World Health Organization (WHO) defines medical waste as all waste generated in the process of providing healthcare services (Chartier et al., 2014). Although, medical waste represents only a small amount of the entire waste generated within a community, medical waste management is considered a critical problem worldwide (Wahab, 2011). According to the World Health Organization, only about 10% to 25% of waste generated from healthcare facilities (HCFs) is considered infectious or hazardous; the remaining 75% to 90% is non-risk (Chartier et al., 2014), but this small percentage of infectious and hazardous waste has the ability to cause health and environmental problems because of its highly infectious properties. If handled improperly, the 10% to 25% can contaminate the entire waste stream, a situation that exist in developing countries with poor practices posing high health and environmental risks and creating high disposal costs through landfilling and incineration. Following desk research of existing studies and literature on the subject of MWM practices in particularly developing countries, this paper aims to review medical waste definitions and characterizations, identify the factors associated with MWM programmes in HCFs with the view to advancing routine management approaches to deliver improvements in the MWM system.

## **2 Context of medical waste**

### *2.1 Definition*

Significant variations exist in medical waste definitions across the world. This is because not all waste generated from healthcare facilities come from clinical activities or core business of healthcare such as treatments and surgeries. While some view medical waste as clinical waste, i.e., waste arising only from actual treatments and diagnoses for example (Jang et al., 2006; Bdour et al., 2007; Verma et al., 2008; Wahab, 2011; Sharafdeen, 2012), some have referred to all waste from healthcare establishments, including waste generated from support activities such as offices and administrative activities as medical or healthcare waste (HCW) (Kumari et al., 2013; Lee & Huffman, 1996; Patil & Pokhrel, 2005; Prem Ananth et al., 2010; Prüss & Giroult, 1999; Sawalem et al., 2009; Tsakona et al., 2007; Tudor et al., 2005). The World Health Organization has defined medical waste as ‘all waste generated by healthcare establishments, research facilities and laboratories including the waste originating from ‘minor’ or ‘scattered’ sources – such as that produced in the course of healthcare undertaken in the home (such as dialysis and insulin injections, etc.)’ (Prüss & Giroult, 1999). In the European Union medical waste is defined in Chapter 18 of the European Waste Catalogue and Hazardous List to include “wastes from human and animal healthcare and related research activities, excluding of wastes from kitchen and restaurants not arising from immediate healthcare”

(EPA, 2002). While the European Waste Catalogue lists what comprises healthcare waste to cover waste from diagnosis, treatment and or prevention of disease in humans and animals and natal care: it does not define what ‘immediate healthcare’ means as such it is not clear whether wastes generated from kitchens in healthcare establishments should be regarded as medical waste since the link between such wastes and ‘immediate healthcare’ activities is not clear. Table 1 below illustrate the discrepancies in the definition and classifications of medical waste. There is no consensus on whether all waste from healthcare facilities and activities should be termed medical waste. In this paper, medical waste definition follows the definition provided by WHO to include all waste that is generated in the course of providing any form of healthcare service. Understanding the scope of medical waste is crucial to developing better management strategies; the classification on medical waste significantly impacts the cost of management and the availability of disposal options (United States Congress, 1990).

**Table 1** Definition and general classification of waste arising from healthcare facilities

<i>Reference</i>	<i>Definition</i>	<i>Classification</i>
Shinee et al. (2008)	Healthcare waste	General waste and medical waste
Mohamed et al. (2009)	Healthcare waste	Hazardous and non-hazardous waste
Miyazaki & Une (2005)	–	Infectious waste and non-infectious waste
Lee et al. (2004)	Medical waste	General waste and special waste
Cheng et al. (2009)	Medical waste	Infectious waste and general medical waste
Nemathaga et al. (2008)	Hospital waste	General waste, medical waste and sharp
Abd El-Salam (2010)	Medical waste	Domestic waste and hazardous waste
Kaisar Alam Sarkar et al. (2006)	Hospital waste	Hazardous and non-hazardous waste
Ruoyan et al. (2010)	Healthcare waste	Medical waste and general waste
Jang et al. (2006)	Medical waste	Tissues and other
Patwary et al. (2009a, b)	Medical waste	Hazardous and non-hazardous waste

Source: Hossain, Santhanam, Nik Norulaini, & Omar (2011)

## 2.2 Classification

Different authors, studies, policies and regulations have classified medical waste based on different criteria. The classifications can be summarised as: type of waste (e.g. clinical or general/domestic-type medical waste, etc.) (Oke, 2008), composition of waste (e.g. chemical and biological properties) (United States Congress, 1990; Prüss & Giroult, 1999), nature of waste (e.g. solid, liquid) and degree of risk (e.g. hazardous or non-hazardous) (Da Silva et al. 2005; Patwary et al. 2011). Despite medical waste streams consisting of a high proportion of non-infectious/hazardous waste—75% to 90% of the

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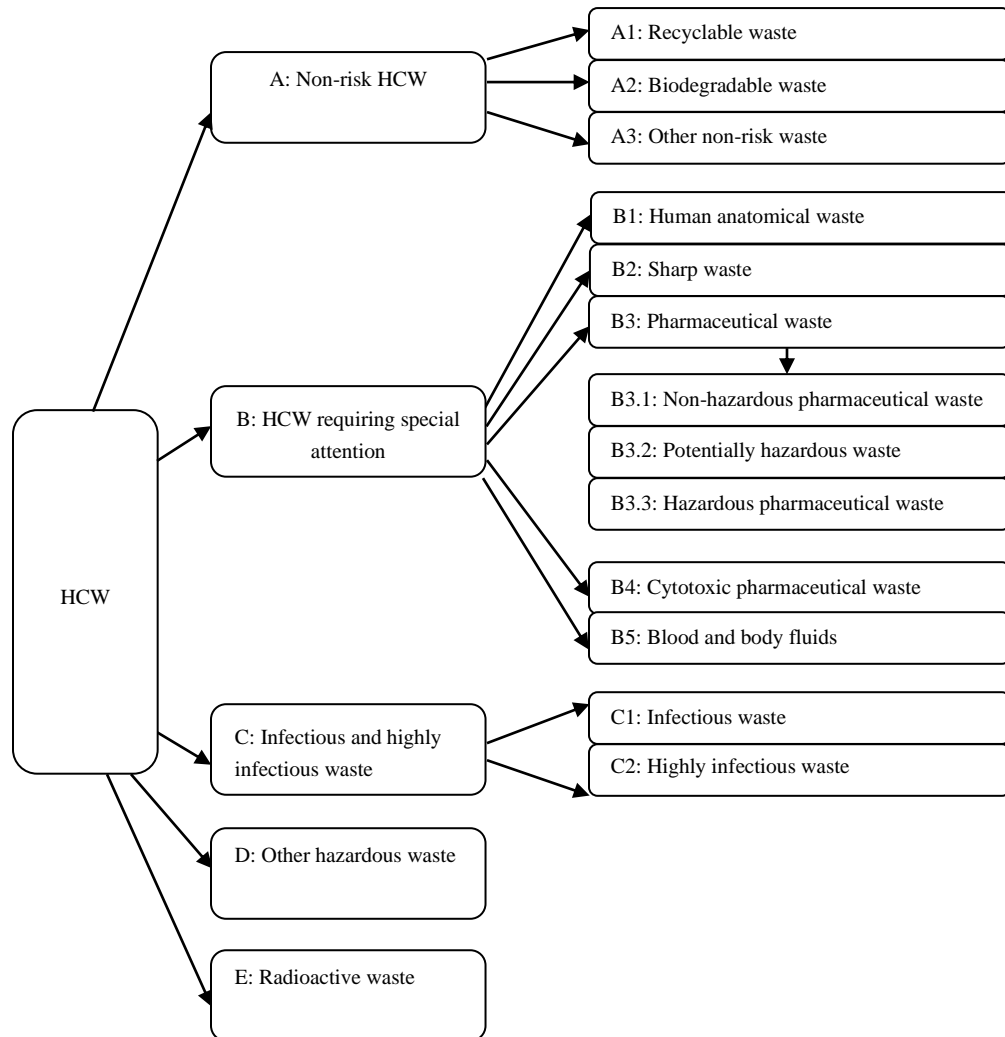
total waste generated from healthcare facilities (Chartier et al., 2014)—studies have placed more emphasis on the 10% to 25% which is considered infectious or hazardous due to the associated health risks. Chartier et al. (2014) without giving any further classification of general waste from healthcare facilities noted that such waste should be handled by municipal waste disposal systems. Table 2 summarises the classification of hazardous medical waste as provided by the World Health Organization.

**Table 2** Categories of hazardous healthcare waste

<i>Waste Category</i>	<i>Description and examples</i>
Infectious waste	Waste suspected to contain pathogens E.g., laboratory cultures; waste from isolation wards, tissues (swabs), materials, or equipment that have been in contact with infected patients; excreta
Pathological waste	Human tissues or fluids E.g., body parts; blood and other body fluids; fetuses
Sharps	Sharp waste E.g., needles; infusion sets; scalpels; knives; blades; broken glass
Pharmaceutical waste	Waste containing pharmaceuticals E.g., pharmaceuticals that are expired or no longer needed; items contaminated by or containing pharmaceuticals (bottles, boxes)
Genotoxic waste	Waste containing substances with genotoxic properties E.g., waste containing cytostatic drugs (often in cancer therapy); genotoxic chemicals
Chemical waste	Waste containing chemical substances E.g., laboratory reagents; film developer; disinfectants that are expired or no longer needed; solvents
Wastes with high content of heavy metals	Batteries; broken thermometers; blood-pressure gauges
Pressurized containers	Gas cylinders; gas cartridges; aerosol cans
Radioactive waste	Waste containing radioactive substances E.g., unused liquids from radiotherapy or laboratory research; contaminated glassware, packages, or absorbent paper; urine and excreta from patients treated or tested with unsealed radionuclides; sealed sources

Source: Prüss & Giroult (1999)

A more comprehensive categorisation of waste from healthcare facilities is provided by the Technical Guidelines on Environmentally Sound Management of Biomedical and Health-Care Waste (see Figure 1).



**Figure 1** Categories of medical waste  
Source: Slovak Environmental Agency (2008)

According to Diaz et al. (2008) one essential element of waste characterisation involves the determination of the composition of waste. A clear understanding of the constituents of the waste stream, especially the constituents of the non-infectious categories of the waste stream, is important in the development and implementation of a realistic waste management plan.

### 2.3 Sources

The most common sources of medical waste are healthcare facilities: hospitals, dispensaries, laboratories, mortuary and autopsy centres and medical research centres

(Prem Ananth et al., 2010). According to the Medical Waste Management Act, Section 117705 of the California Health and Safety Code, any person whose activity or process creates medical waste is a medical waste generator (California Department of Public Health, 2017). Further, the Medical Waste Management Act identifies two types of medical waste generators: (a) Large quantity generators (LQG) (generating medical waste in excess of 200 pounds/month); (b) Small quantity generators (SQG) (generating medical waste short of 200 pounds/months). How small the amount of medical waste generated from any source is, it is an important factor to consider when determining appropriate management options owing to the high risk to human health and adverse effect on the environment.

### *2.3.1 Categories of healthcare facilities*

Healthcare facilities (HCF) are institutions that provide health or medical care for human beings and animals. They include hospitals, clinics, outpatient care centres, and specialised care centres and psychiatric care centres. The World Health Organization defines HCFs to comprise hospitals, isolation camps, burn patient units, primary healthcare centres and feeding centres (WHO, 2014). HCFs comprise all, but are not limited to, teaching hospitals, general hospitals specialist hospitals (orthopaedic, eye clinics and plastic surgery clinics for example) and veterinary clinics. HCFs, especially hospitals and clinics, consume great and varying amounts of items in the course of delivering healthcare (Wahab, 2011). The result of this consumption is the generation of a heterogeneous composition of waste containing various forms of hazardous/infectious properties. Despite the type, size, and nature of healthcare facilities being a significant factor in the nature and amount of waste generation (Abor, 2008; Cheng et al., 2009), the evidence from previous studies show that there is no common criterion for categorizing HCFs (see Table 3).

**Table 3** Categories of HCFs

<i>Reference</i>	<i>Categorization</i>	<i>Criteria</i>
Komilis, Fouki, & Papadopoulos (2012)	- Public	- Ownership
	- Private	
Cheng et al. (2009)	- Medical centers	- Socio-economic status
	- Local (community)	- Nature of care services provided
	- Regional	
	- Independent & others	
Coker et al. (2009)	- Primary	- Size
	- Secondary	- Function
	- Tertiary	
	- Diagnostic	

### **3 Medical waste management practices in healthcare facilities and associated factors**

Baaki et al. (2017) noted that MWM practices in many developing countries still focus on 'safe' management and argued that a successful MWM programme should achieve safe, efficient and sustainable management. Goddu et al. (2007) demonstrated the distinction between MWM practices in developing and developed countries. The study examined MWM practices in hospitals in India and England and reported that, while principles guiding MWM in England ensure 'stringent' compliance, and management practices are satisfactory, the situation in India is still 'bleak' despite the Bio-medical Waste Management and Handling Rules of 1998. While the World Health Organization has reported a relative improvement especially in the areas of regulatory frameworks, national plans, and innovative approaches to addressing waste management issues in developing nations, it identified inadequate funding and resource commitment as the main mitigating factor to proper MWM.

#### **3.1 Regulations**

For regulations regarding hazardous waste management across international borders, the Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal (1989) remains the most fundamental piece of guidelines. The objective of the Basel Convention is to reduce or prevent the adverse effect of hazardous waste on human health and the environment. Its scope of application covers a wide range of both hazardous wastes, including medical waste, (Annex I and VIII) and other wastes, such as household and incineration ash (UNEP, 2011). Beyond this is the more generic Agenda 21 adopted by the United Nations Conference on the Environment and Development (UNCED) in 1992. This recommends measures for waste management to include prevention and minimization; reuse or recycling where possible; treatment by environmentally sound and safe means; and final disposal to appropriate sites. The Agenda 21 also emphasize that any waste producer be responsible for the treatment and final disposal of their waste and if possible, communities should dispose of their waste within their boundaries (Prüss and Giroult, 1999). On the back of these, countries have gone on to establish various regulatory frameworks for the management of wastes generated from healthcare facilities. Table 4 shows legislations/regulations on medical waste management in some developing countries. Although some of these regulations exist, many have argued that they are either poorly formulated, obscure, and inadequately implemented and enforced. For instance, Mbongwe et al. (2008) describe legislation on clinical waste management in Botswana as 'obscure'. Mohee (2005), while praising the enactment of these regulations and policies noted that, most do not adopt a holistic approach, are poorly formulated, and implemented inadequately due to lack of staff awareness, financial inadequacy, poor training initiatives, and monitoring. Moreira et al. (2013) also cited MWM regulations such as National Health Surveillance Agency (ANVISA) Resolution No. 306:2004 and National Environmental Council of Brazil (CONAMA) Resolution No. 358:2005 in Brazil as been up to date but reported that no performance assessment was conducted following the implementation of MWM plans. Manga et al. (2011) noted that for the formulation and implementation of any waste

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management programme to be effective, it must be within a ‘specific and sustainable regulatory policy framework’.

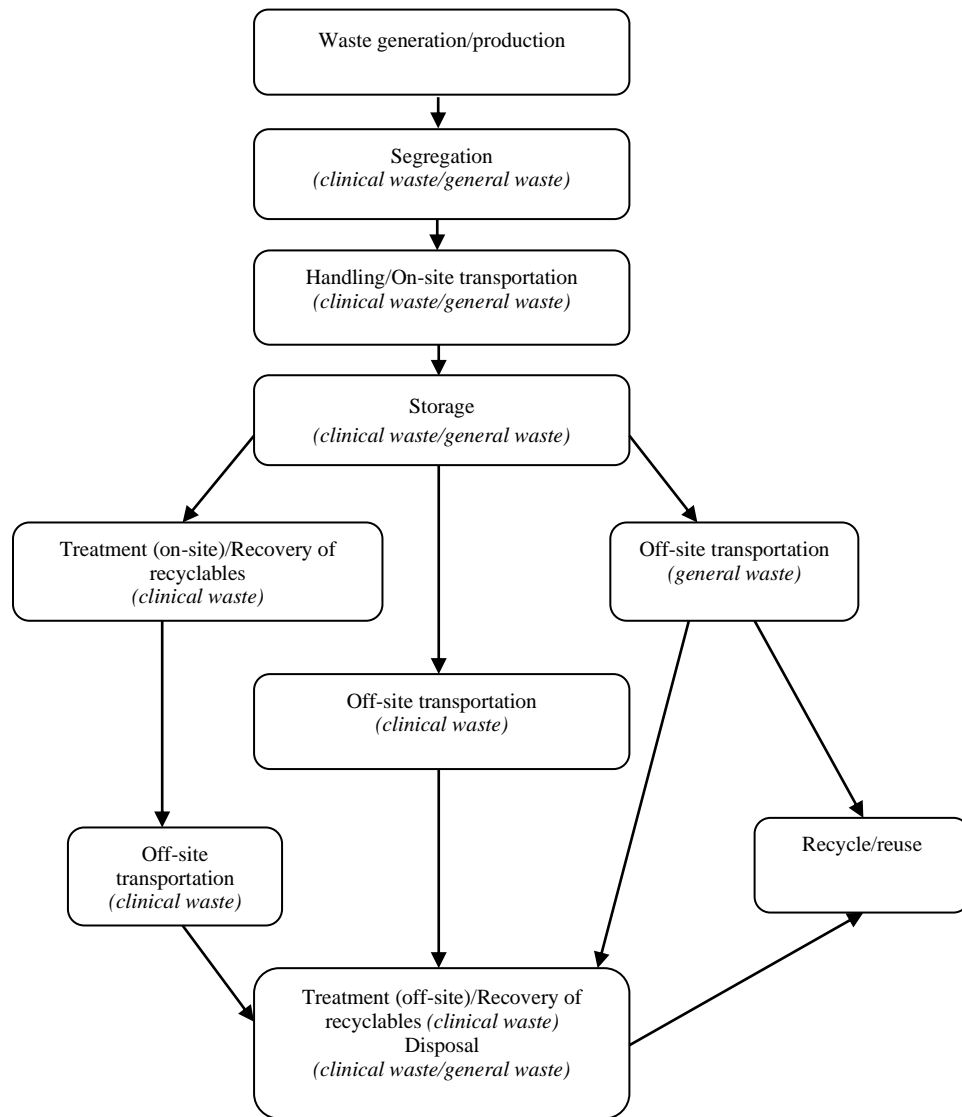
**Table 4** Waste management regulations in some developing countries

<i>Reference</i>	<i>Country</i>	<i>Legislation</i>
Goddu (2007); Chandana, Sri, Bhargav, & Gayathri (2018)	India	Bio-medical Waste Management and Handling Rules of 1998; Biomedical Waste Management Rules 2016
Da Silva et al. (2005); Moreira, et al. (2013)	Brazil	National Health Surveillance Agency (ANVISA) Resolution No. 306:2004; National Environmental Council of Brazil (CONAMA) Resolution No. 5:1993; Resolution No. 283:2001; Resolution No. 358:2005
	Egypt	Law of the Ministry of Environmental Affairs and Ministry of Health and Populations
Manga et al. (2011)	Mongolia	2002 Removal & Disposal of Hazardous Wastes and the 2003 Improvement of Healthcare Waste Management
Mohee (2005)	Mauritius	Act 1925 and the 2001 Standards for Hazardous Waste Regulations
Abah (2011)	Nigeria	National Policy on Healthcare Waste, 2007 (Draft)
Ali, Wang, & Chaudhry, (2017); Dawar (2017)	Pakistan	Healthcare Waste Management Rules 2005

### 3.2 *Practices and associated factors*

Medical waste management remains a global problem. The World Health Organization (WHO) has provided a general guidebook for the management of wastes arising from healthcare provision. It sets out the guidelines for ‘safe’ and ‘sustainable’ management of these wastes. Understanding the medical waste management process from generation to disposal is vital to its management. There is wide literature and studies on medical waste management practices in both developing and developed nations (Abah, 2011; Abor, 2008; Akter, 2003; Bdour, Altrabsheh, Hadadin, & Al-Shareif, 2007; Chaerul, Tanaka, & Shekdar, 2008; Coker et al., 2009; Da Silva et al., 2005). The following constitutes the MWM process: (a) generation, (b) segregation, (c) on-site transportation, (d) temporary storage, (e) treatment/disinfection, (f) off-site transportation, (g) final disposal, (h) recycle/reuse (see Figure 2 for an illustration of the process flow). To note in the medical

waste management process is the absence of waste minimization, which clearly do not take into account one of the essential elements of the waste management hierarchy: waste prevention and minimization. Until recently, the general disposition toward healthcare waste is to consider it bound for disposal once generated, with little attempts made at instituting measures to prevent and minimize generation.



**Figure 2** MWM from generation to disposal

### *3.2.1 Generation*

Medical activities are the fundamental sources of medical waste generation. Most of the waste is non-risk. It is therefore important to understand factors that result in the nature, and amount of waste generated at healthcare facilities. Abor (2008) and Gitipour, Pour, & Firouzbakht (2017) identified type of healthcare services provided by a hospital; number of beds; economic, social and cultural status of patients; nature of segregation programme, and the general condition of the area the hospital is located as factors responsible for the amount and nature of waste generated by healthcare facilities. Sharma & Gupta (2017) found that bed capacity and number of doctors were key factors affected quantity of waste generation. In Taiwan, Cheng et al. (2009) observed that insurance reimbursement and number of beds were the chief factors predicting the generation of infectious waste. Komilis et al. (2012), observed the rate of waste generation from public and private hospitals in Greece. Public hospitals generated between 0.012 kg/bed/day to 0.72 kg/bed/day, while private hospitals generated between 0.0012kg/bed/day to 0.49 kg/bed/day. The lowest generation rates for both public and private hospitals was from psychiatric hospitals while the highest generation rate for public and private hospitals was from university hospitals and birth clinics respectively, agreeing with Abor (2008) that the nature of healthcare services provided by healthcare facilities factor in the amount of waste generated from HCFs. In a study in 2006 to develop a standardized measurement unit for waste generated from healthcare activities, Tudor (2006) grouped these factors into two main categories: (a) Department type, and (b) Activity levels.

### *3.2.2 Segregation*

This entails separating different types of waste streams according to their classifications. Waste segregation is the most essential aspect of the MWM process, and it is the least adhered to in developing nations. It is either not practiced or is carried out in a highly unsatisfactory manner (Ali, Wang, & Nawaz, 2017; Baaki, Baharum & Akashah, 2017). The aim is to separate infectious/hazardous waste from non-infectious/non-hazardous waste and prevent contamination. Appropriate segregation goes beyond just separating clinical waste from general medical waste as this would lead to better treatment and disposal practices as well as recovery of potential recyclables. Wastes with very high infectious properties such as pathological and anatomical waste must be separated from pharmaceutical waste; the same must be done with sharps and radioactive waste, for example. A study in Bangladesh by Akter & Trankler (2003) showed that apart from separating syringes/needles, hospitals did not practice waste segregation, while Abor (2008) observed in South Africa that apart from separating clinical waste from general waste, further segregation was not practiced. Factors responsible for improper segregation practices have been identified to include poor risk awareness (UN-Habitat, 2006); lack of awareness, training and badly formulated policies (Mohee, 2005); improper MWM plan implementation strategies (Moreira et al., 2013). Segregation must begin at source, i.e. at the point of waste generation. Chartier et al. (2014) noted that at the point of waste generation, segregation is the absolute responsibility of hospital personnel. Table 4 shows color-coding and labelling best practice as recommended by WHO.

**Table 4** Color-coding recommendations for medical waste

<i>Type of waste</i>	<i>Color of container and markings</i>	<i>Type of container</i>
Highly infectious waste	Yellow, marked “HIGHLY INFECTIOUS”	Strong, leak-proof, plastic bag, or container capable of being autoclaved
Other infectious waste, pathological and anatomical waste	Yellow	Leak-proof plastic bag or container, labeled with biohazard symbol <sup>a</sup>
Sharps	Yellow, marked “SHARPS”	Puncture-proof container
Chemical and pharmaceutical waste	Brown	Plastic bag or container
Radioactive waste <sup>1</sup>	-	Lead box, labeled with the radioactive symbol <sup>b</sup>
General healthcare waste	Black	Plastic

Source: Prüss &amp; Giroult (1999)

<sup>1</sup>Only generated in major technologically advanced hospitals

### 3.2.3 Handling, on-site transportation and storage

Handling and transportation personnel must be well equipped with Personal Protection Equipment (PPE) such as masks, protective eyewear, protective clothing, puncture- and water-proof boots, general purpose gloves, hard hats (Abor, 2008; Razali, 2010; Vieira et al., 2009). However, studies have reported various inadequate and inappropriate waste handling and on-site transportation practices in developing countries (Coker et al., 2009; Oli, Ekejindu, Adje, Ejiofor, Ibeh, & Ubajaka, 2016). For instance, Coker et al. (2009) found that wastes were collected at the point of generation into inappropriate equipment such as metal dustbins, drums, baskets, pans, cartons, buckets, bowls and transported on shoulders by waste handling personnel instead of appropriate wheeled bins. The study further suggests the lack of awareness or training on the potential risks of improper waste handling as a possible factor.

Regarding temporary storage, Chartier et al. (2014) suggest that unless a cold room is provided for temporary storage of infectious/hazardous medical waste, such wastes should not be stored for longer than 3 days and 2 days in a temperate climate during winter and summer respectively; and 2 days and one day during the cool and hot seasons in warm climates respectively; cytotoxic should be stored in separate secure locations; and radioactive stored behind lead shielding in dispersion-proof containers. Temporary storage areas should also be inaccessible to unauthorized personnel and animals such as rodents, dogs and cats for example. Temporary storage facilities have been found to be non-existent, inappropriate and poorly operated (Ali, Wang, & Nawaz, 2017; Baaki, 2014; Coker et al., 2009). Coker et al. (2009) found that all types of medical wastes awaiting disposal were stored in a common area. Baaki (2014) on the other hand found that inappropriate storage media were used to store medical wastes and for periods exceeding temporary storage recommendations.

### *3.2.4 Treatment, off-site transportation and disposal*

Treatment is the process of disinfecting infectious medical waste. Several treatment technologies exist for treating infectious medical waste. Incineration or combustion has been identified as the most widely used method of waste treatment in developing countries (Abor, 2008; Diaz et al., 2005; Razali, 2010). Lee and Huffman (1996) reported incineration as the best treatment technology for medical waste treatment as it significantly reduces the waste volume, can destroy hazardous organics and pathogens and render the waste unrecognizable. However, despite the existence of rotary kiln incinerators, which have two combustion chambers and air pollution control, Diaz et al. (2005) observed that combustion of medical waste generates chemical compounds and particulate matter that can potentially have health effects on humans and the environment, especially in the case of developing countries where makeshift combustion devices and systems are prevalent. The lack of management commitment, financial and technological capacity has been identified as factors hindering the establishment and operation of appropriate treatment facilities in developing countries (Abah & Ohimain, 2011; Baaki et al., 2017).

While some studies have shown prevalent practices of disposing considerable amounts of medical waste around the premises of healthcare facilities in developing nations (Akter & Trankler, 2003; Coker et al., 2009; Baaki, 2014), other studies show that off-site transportation of medical waste is generally outsourced (Abor, 2008; Diaz et al., 2005; Razali, 2010). The waste is then transported to either landfills or treatment and disposal facilities. This, however, does not eliminate improper handling and transportation practices, especially in developing countries (Abor, 2008; Coker et al., 2009; Baaki, 2014). Chartier et al. (2014) noted that, it is the responsibility of the healthcare facility to properly package medical waste and recommends that transportation of infectious/hazardous medical waste should follow WHO Guidelines for the Safe Transport of Infectious Substances and Diagnostic Specimens.

In choosing disposal options, it is not enough that the option provides safe disposal; it should as well be a sustainable option. Poor practices such as using municipal bins, dumping grounds and burial of such waste as placenta/foetuses within and around the hospital premises even among residential areas have been reported in some developing countries (Abor & Bouwer, 2008; Akter & Trankler, 2003; Oke, 2008; Coker et al., 2009; Patwary et al., 2011) making it possible for wastes with hazardous and infectious properties to be accessible to children scavenging dumpsites (Coker et al., 2009; Oke, 2008). This shows the lack of awareness on the health and environmental risks associated with such disposal practices (Patwary et al., 2011). Abah & Ohimain (2011) argue that the capacity to dispose huge amounts of healthcare waste is lacking in many developing countries. Financial and social factors might also affect certain disposal practices. Chartier et al. (2014) observed that in certain countries, religious and cultural practices might make it unacceptable to collect anatomical waste in yellow bags and dispose of it as per the MWM policy; such should therefore be disposed of safely in accordance with local customs. Table 5 shows best practice treatment/disposal technologies/methods of various categories of medical waste as recommended by the World Health Organization.

**Table 5** Treatment/disposal methods/technologies for medical waste<sup>1</sup>

<i>Technology</i>	<i>Method</i>	<i>Waste Handled</i>
Thermal	<ul style="list-style-type: none"> <li>- Autoclave</li> <li>- Hybrid autoclave</li> <li>- Continuous steam</li> <li>- Microwave technologies</li> <li>- Frictional heat treatment</li> <li>- Dry heat</li> <li>- Incinerators</li> </ul>	<ul style="list-style-type: none"> <li>- Autoclaves: cultures, stocks, sharps, material contaminated with blood and body fluids, isolation and surgery waste, laboratory waste excluding chemical waste, soft waste from patient care etc.</li> <li>- Microwave: same as for autoclaves plus pathological waste, bottles containing fluids.</li> <li>- Frictional heat: cellulosic material, glass, plastics, metals, liquids and pathological waste.</li> <li>- Dry heat: sharps and small amounts of infectious waste.</li> <li>- Incinerators: same as for autoclave plus large beddings, cadavers, large anatomical remains, cytotoxic waste.</li> </ul>
Chemical	<ul style="list-style-type: none"> <li>- Chlorine</li> <li>- Glutaraldehyde</li> <li>- Lime slurry</li> <li>- Calcium oxide</li> <li>- Alkaline hydrolysis</li> </ul>	<ul style="list-style-type: none"> <li>- Chlorine based: liquid waste, infectious waste, microbiological cultures, sharps.</li> <li>- Alkaline hydrolysis: pathological waste, organs, tissues, cadavers, anatomical parts, stocks and cultures, chemotherapeutic agents.</li> </ul>
Irradiative	<ul style="list-style-type: none"> <li>- Electron beam</li> <li>- UV-C (germicidal UV)</li> <li>- Irradiation</li> </ul>	<ul style="list-style-type: none"> <li>- Radioactive waste</li> </ul>
Biological	<ul style="list-style-type: none"> <li>- Enzyme treatment</li> <li>- Composting</li> <li>- Vermiculture</li> </ul>	<ul style="list-style-type: none"> <li>- Biological waste</li> </ul>

Source: UNEP (2013)

<sup>1</sup>General waste not reflected. According to Prüss & Giroult (1999), such wastes should be handled by municipal disposal mechanisms

### **3.2.1 Recycling/Reuse**

As mentioned earlier, the percentage of infectious/hazardous waste constitutes only about 10% to 25% of the total waste generated from healthcare institutions with the remaining 75% to 90% considered non-risk/domestic-type. This 75% to 80% of the waste stream has high recycling potential (Hutchins & White, 2009; Scally, 2009; Marmot, 2010), however, extensive studies discussing the potential of recycling wastes from healthcare facilities particularly in developing countries are lacking. A study by Hossain et al. (2011) involving 14 countries, mostly developing countries, found that only 3 out of the 14 recycled parts of the waste generated from healthcare facilities. Lack of, or poorly formulated regulations and policies, poor infrastructural state, and low level of technological advancement could be seen as factors (Mbongwe et al., 2008; Mohee, 2005). Also, the fact that if improperly handled, non-risk waste could easily get contaminated could be the reason behind limited enthusiasm towards medical waste recycling, particularly in developing nations (Baaki et al., 2017).

After examining the MWM practices in developing nations, the following key factors have been identified:

- Lack or poorly formulated MWM specific regulations and policies.
- Poor risk awareness, sensitisation and training on MWM.
- Poor financing and inadequate investment in MWM programmes.
- Influence of social factors such as cultural norms and social status.
- Improper implementation of policies and best practices.
- Poor infrastructure and low level of technological advancement.

## **4 Achieving integrated sustainable medical waste management (ISMWM) in healthcare facilities**

The heterogeneous composition of medical waste has made discussions on its management primarily focused on treatment and disposal technologies in what seems to suggest that a one-size-fits-all technological solution to deal with its management could be the solution. This has left, especially developing nations, with serious burdens. According to Prem Ananth et al. (2010) healthcare waste must be seen as “contiguous blocks of individual actions requiring appropriate management strategies to control it.” Waste definition and composition must be explicitly understood before appropriate management strategies can be developed. Sustainable MWM strategies must be formulated bearing in mind that first, waste generation has to be avoided (where possible and applicable); second, minimisation of waste generation; third, adopting appropriate treatment methods; and fourth, recycling initiatives. The first point of consideration is whether such waste should end up at disposal mechanisms at all. This would create an atmosphere for conscious attempts to minimize waste generation, observe detailed segregation practices, identify potential recyclables thereby ensuring that only waste that defy any of these measures ends up at disposal mechanisms.

The concept of integrated sustainable waste management (ISWM), set up in the early 1990s, tackles primarily waste management issues in developing countries.

Formulated to counterpoise the common technology-driven approach of waste management, it is built upon the overarching concept of sustainability. The ISWM identifies three essential perspectives of waste management (Klundert, Anschütz, 2001): (a) What? (scope of the waste system, covering physical composition, planning and management concerns such as strategic planning, financial appropriation and management, public participation); (b) Who? (stakeholders – all those involved with and affected by the waste management situation); and (c) How? (path to achieving strategic objectives and implementing waste management solutions). The concept of ISWM, however, is a primarily municipal solid waste management concept. Only in 2007, the World Health Organization published what it called ‘WHO core principles’ for safe and sustainable management of health care waste. The “WHO core principles” for safe and sustainable management of medical waste emphasizes the importance of the active participation of all stakeholders involved in the medical waste management chain in order to successfully implement sustainable medical waste management. The WHO core principles stipulate that, all associated with financial and or supporting healthcare activities should provide for the cost of managing healthcare waste. Also, manufacturers of healthcare products should bear in mind the concerns of MWM while developing and marketing their products (WHO, 2007).

Based on the identified associated factors of MWM in developing countries, the following recommendations can be made:

#### *4.1 Regulations and policies*

##### *4.1.1 Strategies:*

- While there are international recommendations, specific regulations formulated within a sustainable design framework at both external (national/ministry) and internal (healthcare facilities) levels would provide legally binding provisions on formulated policies. For instance, a disposal regulation on diverting certain waste streams such as potential recyclables from landfill and incineration. Such legislation could prohibit disposal of such waste streams through high disposal costs and severe fines.
- Presently, there are a variety of terms used to refer to waste generated from healthcare facilities. There is need for a single definition and classification criteria of waste generated from healthcare facilities. While this could be achieved at a global level, national waste management policies should clearly define and classify all waste arising from healthcare activities.

#### *4.2 Implementation*

Implementation is one of the important elements of any plan if it is to be successful. Only a well-executed plan could yield useful results.

##### *4.2.1 Strategies:*

- Goal setting/action plans: Despite the overarching objectives of MWM plans, implementation involves setting short-term goals and action plan frameworks,

the day-to-day operational activities critical to the actualization of the bigger picture.

- Measurement of waste generation rates: This is essential as you cannot manage what you don't know. Appropriate measurement units should be adopted. Tudor (2007) proposed a 'kg/person/month' standardized measurement unit for medical waste generation, arguing that other units of measurements, for instance, kg/bed/day were prone to fluctuations, failed to take into account proper measurement of waste generated from non-patient activities and could provide false data as beds could be either unoccupied or over-occupied.
- Waste minimization and extensive segregation practices: Waste minimization and segregation should take into account recycling potential of medical wastes. As it has been noted, 75% to 90% of waste generated from healthcare facilities in domestic-type waste with high recycling potentials. By adopting waste minimization approaches such as sustainable purchasing, and segregating potential recyclables from the waste stream, the total amount of waste generated or heading down treatment and disposal options would be significantly reduced, resulting in resource efficiency, costs savings on disposal and less adverse impact on the environment.
- Performance assessment: Performance evaluation and measurement is a way of making sure that performed actions are yielding desired results, and if they are not, what corrective actions to be instituted. A performance evaluation and measurement framework should be in place to assess the level of conformity to set goals and objectives.

#### *4.3 Sensitisation, awareness and training programmes*

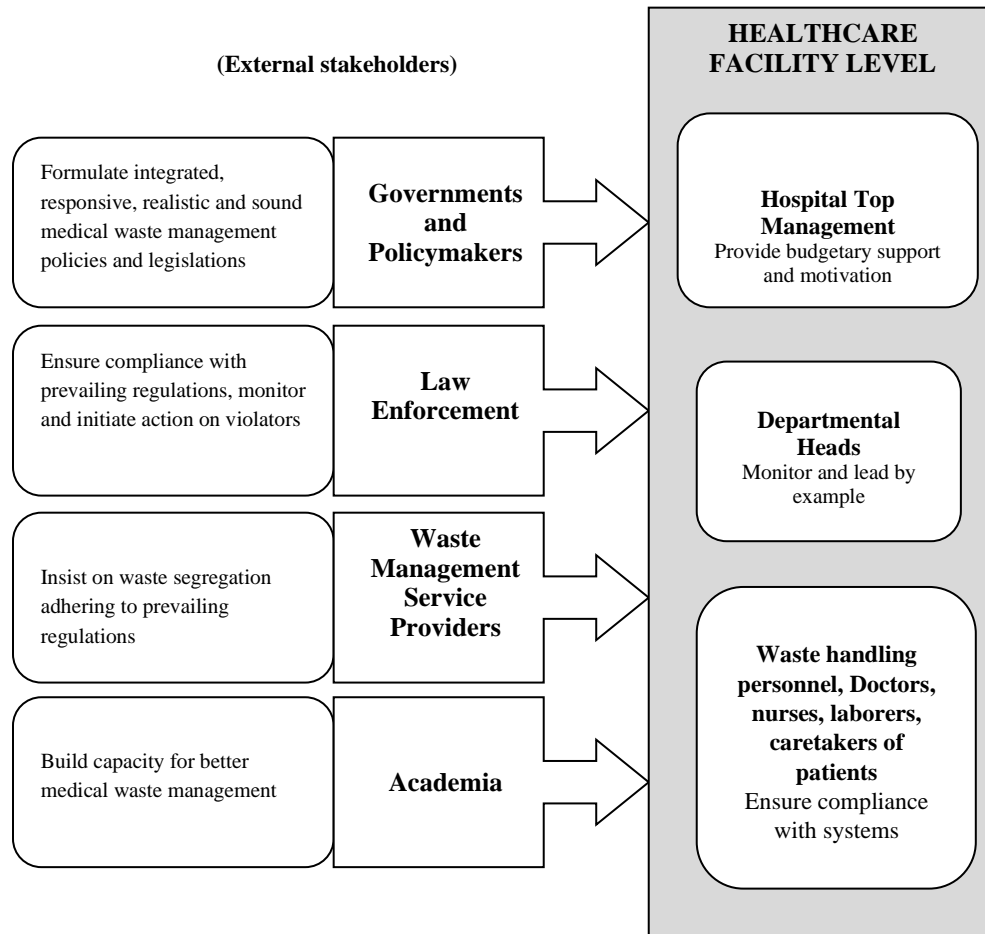
The success of any MWM plan implementation would be greatly affected by how well people are aware of the issues surrounding MWM. This suggest core focus on the people in terms of conditioning individuals to be aware of health and environmental risks of MW as well as understand the objectives and aspirations of the waste management programme.

##### *4.3.1 Strategies:*

- Training programmes should be dully administered to waste generators, waste handling staff, and even patients and their relatives on both the risks and recycling potentials of medical waste.
- Constant awareness and sensitisation should be created through signage posting to discourage waste generation as well as encourage people to practice the simple acts of putting waste types in their designated waste collection mediums.

#### 4.4 The role of stakeholders

Designated roles of stakeholders, i.e., everyone involved with and or affected by a MWM programme, should be detailed in MWM policies and action plans that should in turn be duly and clearly communicated to all stakeholders (see Figure 3).



**Figure 3** Distribution of responsibilities  
Source: Adapted from Prem Ananth (2010)

## 5 Conclusion

To achieve holistic and successful waste management practices, MWM has to be understood from the point of generation all through to disposal. While most of the associated factors of MWM have been identified to being of managerial nature, attempts to curb the situation have still taken a more technological route. In some countries, specific MWM regulations and polices do not exist. In some where they do exist,

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implementation has been either poor or non-existent. Waste management staff and personnel often lack knowledge and basic skills. Managerial incompetency and lack of dynamic strategies pose a huge challenge to any complex technology. The formulation of MWM-specific regulations, policies and frameworks at both external and internal levels is the starting point. Reliance on a one-solution-fits-all could result in hiking costs of MWM programmes, especially with regards to disposal options. This paper thus argues that the success of a safe, efficient and sustainable MWM programme, particularly in developing countries must be formulated around a holistic and integrated process, where simple management strategies assume a much more predominant role. It is important to note that this paper only relied on a general review of existing literature on MWM, as such the proposed recommendations are broad. It is suggested that further research empirically investigate how these broad recommendations could be applicable in specific MWM situations in specific developing countries or regions.

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