J. sustain. environ. peace (2020) 3(2) 34-40

WANGARI MAATHAI INSTITUTE FOR PEACE AND ENVIRONMENTAL STUDIES

Journal of Sustainability, Environment and Peace

ISSN: 2663-4627

Homepage: http://www.jsep.uonbi.ac.ke

Hazardous Biomedical Waste Management in a Level Four Private Hospital in Nairobi County, Kenya

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Article history
Received: 28 October 2019
Received in revised form: 28 June 2020
Accepted: 1 July 2020
Available Online: 6 July 2020

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Key words
Hazardous biomedical waste
waste segregation
incineration
waste management

ABSTRACT

The objectives of the study were to characterize hazardous biomedical waste and assess how the waste managed in a Level Four private Hospital in Nairobi County, Kenya. The hospital selected for the study is one of the largest in the County and was therefore a suitable case study on account of its expected volume and diversity of hazardous biomedical waste. A stratified random sampling procedure was used to select 53 respondents from the medical, teaching administrative and housekeeping departments of the Hospital. Primary data were obtained using questionnaires, informal interviews, observation and photography. Secondary data were derived from hospital records, hospital magazine as well as the Hospital website. Other secondary data sources included research reports, policy documents, unpublished theses. Data analysis was carried out using frequencies and percentages. The study findings indicated the Hospital generated various hazardous biomedical wastes associated with patient, laboratory and support services. The most frequently generated waste was sharps waste which accounted for 92.8 per cent of the patient services categories. Infectious, pathological and chemical wastes accounted for 78.5 per cent, 71.4 per cent and 64.3 per cent respectively, of the patient service categories. The study also established that waste segregation using colour coded bins was well entrenched in the hospital although waste mixing occurred. All hazardous biomedical wastes were treated and onsite waste transportation was conducted using trolleys and carts, as per the provisions of Kenya's The Environmental Management and Co-ordination (Waste Management) Regulations, 2006. A significant proportion of the study respondents (75.5 per cent) were aware of the various policies governing hazardous biomedical waste management and waste was mainly managed through incineration and private waste collection. The main waste management challenges in the hospital were the mixing of wastes, waste spillage as well as ignorance of waste management procedures by waste handlers. It is concluded that although the hospital was safely and effectively managing hazardous biomedical waste through compliance with the provisions of the Environmental Management and Co-ordination (Waste Management) Regulations, 2006, it nonetheless needed to address the challenges associated with mixing of waste at the departmental and waste handling levels, as well as the environmental implications of the use of incineration as the main the main waste management practice.

1. Introduction

Biomedical wastes consist of a wide and complex array of solid and liquid wastes generated in healthcare facilities, research centres and laboratories associated with medical procedures (Chartier et al. 2014). They include a broad range of materials, from used needles and syringes to soiled dressings, body parts, diagnostic samples, blood, chemicals, pharmaceuticals, medical devices and radioactive materials and are generated during the diagnosis, testing, treatment, research or production of biological products for human or animals (WHO India 2019). Biomedical waste can be categorized into hazardous and non-hazardous (general) each accounting for 15 per cent and 85 per cent respectively, of the total waste (WHO 2018). Hazardous waste is any waste that poses a severe threat or is potentially harmful to human health or the natural environment if not properly disposed of or managed. Examples of such waste include contaminated gloves, human tissue, pesticides, herbicides and industrial solvents. On the other hand, general or non-hazardous waste does not pose any particular biological, chemical, radioactive or physical hazard/risk and can therefore be disposed off using regular public/municipal waste disposal methods and systems (WHO 2018). Examples of such wastes include waste paper, plastics and glass. However, there are variations between countries in the proportions of hazardous and non-hazardous waste. For instance, 25 per cent and 26.5 per cent of biomedical waste produced in Pakistan and Nigeria, respectively is classified as hazardous (Azage and Kumie 2010).

Please cite this article as: Othigo E. A. and Moronge J. (2020). Hazardous Biomedical Waste Management in a Level Four Private Hospital in Nairobi County, Kenya. J. sustain. environ. peace 3 (2) 34–40

It is documented that the situation could be worse in Kenya, with 50 per cent of waste in some facilities classified as infectious, largely due to poor waste management strategies (Government of Kenya 2015).

Although, hazardous biomedical waste accounts for a relatively smaller percentage of the total waste generated by healthcare facilities globally, its impact can be significant if the waste is not properly managed. As already noted, it poses potential health hazards to health care workers, the public and the natural environment because it is infectious, toxic or radioactive (Chartier et al. 2014, Capoor and Bhowmik 2017). Table 1 shows examples of infections that can be caused by hazardous biomedical waste. Accordingly, different types of infections are caused by bacteria and viruses through various transmission agents. As far as the natural environment is concerned, hazardous biomedical waste has been associated with the contamination of drinking, surface, and ground waters especially in waste landfills that are not properly constructed (WHO 2018). Incineration of waste has been linked to air pollution, ash residues and the spread of heavy metals in the environment (Manzoor and Sharma 2019, Gautum et al. 2010). It is also documented that the use of chemical disinfectants to treat biochemical waste can lead to release chemical substances into the environment (WHO, 2018).

Table 1: Some infections that can be caused by hazardous biomedical waste

Type of Infection	Infective agent	Transmission agent
Gastrointestinal infections	Enterobacteria (salmonella, shigella, etc.)	Faeces, vomit
Respiratory infections	Mycobacterium tuberculosis, measles virus, Streptococcus pneumoniae,	Saliva, inhaled secretions
Eye infections	Herpes virus	Eye secretions
Skin infections	Streptococcus	Pus
Anthrax	Bacillus anthracis	Skin secretions
Meningitis	Neisseria meningitidis	Cerebro-spinal fluid
AIDS	Human Immunodeficiency Virus (HIV)	Blood, sexual secretions, other body fluids
Haemorrhagic fever	Lassa, Ebola, Marburg, and Junin viruses	Blood and secretions
Viral hepatitis A	Hepatitis A virus	Faeces
Viral hepatitis B and C	Hepatitis B and C viruses	Blood and other biological fluids
Avian influenza	H5N1 virus	Blood, faeces
COVID 19	Severe acute respiratory syndrome corona virus (SARS CoV2)	Infected secretions via respiratory droplets

Source: Prüss et al. (1999), Tesini 2020

Globally, the volume of hazardous biomedical waste produced has been on an upward trajectory due to rapid expansion of the healthcare sector. Typically, developing countries produce composite biomedical waste ranging from 0.5 to 2.5 kg per bed per day (Zafar 2019). Safe and effective management of biomedical waste is both a legal requirement and an important social responsibility (Deva 2019). For instance, the Constitution of Kenya 2010 (Section 42) makes provisions for each person's entitlement to a clean and healthy environment. Due to the risks associated with hazardous biomedical waste, it is important to safeguard human health and safety though proper management of such waste. The main objective of this study was to characterize hazardous biomedical waste associated with the delivery of patient, laboratory and support services as well as assess how the waste is managed in a Level Four private Hospital in Nairobi County. Waste characterization provides information that can be used in the development of safe and effective waste management strategies and policies.

2. Materials and methods

2.1 Study Area

The study was carried out in a private Level Four Hospital in Nairobi County. The Hospital is located in the Industrial Area, within the Starehe Constituency. It is located in an area with mixed land uses, including industrial, commercial and residential uses. Its location is also proximate to the Ngong River. At the time of the study, the hospital had a bed capacity of 216 and 485 staff, composed of medical, teaching, administrative and support staff.

2.2 Data Collection and Analysis

Both primary and secondary data were collected for the study. Primary data were collated through the administration of questionnaires, informal interviews, observation and photography. Questionnaires were administered on hospital staff from various departments, including medical, teaching, administrative and support staff. A stratified random sampling procedure was employed to select 53 study respondents consisting of 8 doctors, 9 nurses, 4 pharmacists, 10 laboratory technicians, 4 radiologists, 5 teaching staff members, 6 administrative staff members and 7 support staff members. The doctors and nursing staff were sampled from eight departments (one doctor and one nurse from each department) in the hospital namely: casualty ward, consultants' clinic, theatre, dental unit, well mother clinic, well baby clinic and dialysis unit with an extra nurse from the intensive care unit. Using an observation checklist and photography, data were also obtained from visits to casualty ward, consultants clinic, doctors' plaza, theatres, dialysis unit, laboratories, x-ray unit, pharmacy, the nursing school, administration offices, laundry and kitchen. Secondary data were obtained from hospital documents, including the hospital magazine, booklets as well as the hospital website. Other secondary data sources included published research reports on hazardous biomedical waste, policy documents (such as NEMA's The Environmental Management and Co-ordination (Waste Management) Regulations, 2006 and the Ministry of Health's Health Care Waste Management Plan 2016-2020) books (such as Prüss, A., E. Giroult, E. and Rushbrook, P. (1999) (eds) Safe management of wastes from health-care activities as well as unpublished research theses and reports. Data have been analysed using frequencies and percentages. The use of these basic statistical techniques was due the nature and amount of data available given that this was a case study of a single health facility.

3. Results and discussion

3.1 Characterization of hazardous biomedical waste in the Hospital

The study findings indicate that the Hospital generated various hazardous wastes. The main waste sources were associated with patient services, laboratory services and support services. Table 2 indicates hazardous biomedical wastes associated with delivery of these services. The most frequently generated waste was sharps waste, which accounted for 92.9 per cent of all services categories. It was generated in all patient category categories apart from in the provision of radiology services. Sharps waste included used and unused hypodermic, intravenous or other needles, infusion sets, knives, blades, broken glass, and syringes with attached needles. The other significant wastes were infectious and pathological wastes that were cited in 78.6 per cent and 71.4 per cent, respectively of the services categories.

Table 2. Hazardous biomedical wastes associated with patient services

Service Category	Type of biomedical waste					
	Pathological waste	Radioactive waste	Chemical waste	Infectious waste	Sharps waste	Pharmaceutical waste
Patient services						
Medical services	✓	-	-	✓	✓	✓
Sluice room	-	-	✓	✓	✓	✓
Operating theatres	✓	-	✓	-	✓	-
General wards	-	-	-	✓	✓	✓
Isolation ward	✓	-	✓	✓	✓	✓
Dialysis unit	✓	✓	✓	✓	✓	✓
Dental unit	-	-	-	-	✓	✓
Emergency room	✓	-	-	✓	✓	✓
Outpatient clinic	✓	-	✓	✓	✓	✓
Autopsy room	✓	-	✓	✓	✓	-
Radiology	-	✓	✓	-	-	-
Laboratory services						
Microbiology	✓	-	✓	✓	✓	-
Pathology	✓	-	✓	✓	✓	-
Support services						
Laundry	✓	-	-	✓	✓	-
Frequency	10	2	9	11	13	8
Percentage[1]	71.4%	14.3%	64.3%	78.6%	92.9%	57.1%

✓ indicates the waste is generated in respective patient services category

[1]Percentage is computed on the basis the frequency of each waste type as a proportion of the total number of types of service categories (patient services, laboratory services and support services categories i.e. 14 categories). This was used as a surrogate indicator of waste type significance, since the hospital did not have a record of the quantity of waste generated per bed per day, at the time of the research.

Source: Fieldwork 2013

These research findings are collaborated by Chaurasia et al. 2013 and Qdais et al. 2006. In a study of quantification and characterization of biomedical waste at Satna City in India, Chaurasia et al. 2013 established that infectious waste consisting of human anatomical waste and solid wastes such dressing, bandages and materials contaminated with blood accounted for highest quantity (65.49 per cent) the total of waste generated per bed per day in 2012. Qdais et al. 2006 study on the characteristics of the medical waste generated at the Jordanian hospitals, established that the infectious wastes accounted for 83 per cent of the total hazardous waste followed by sharps waste which accounted for 12 per cent of the total waste. Pathological, cytotoxic and pharmaceutical waste categories accounted for the rest of the waste.

3.2 Hazardous biomedical waste management in the Hospital

3.2.1 Waste segregation, treatment, storage and transportation

The Environmental Management and Co-ordination (Waste Management) Regulations, 2006 make provisions for biomedical waste segregation, treatment, storage and transportation. Accordingly, any person who generates biomedical waste is required to segregate the waste at the point of generation and all stages thereafter. The significance of segregation is to reduce the risk of occupational injury and infections and diseases particularly among waste handlers (De Titto and Savino 2012). Furthermore, all waste is supposed to be treated before storage and eventual disposal. The Regulations further provide that biomedical waste should not be stored above 0º C for more than seven days without the written approval of the lead agency. As far as transportation of the waste is concerned, only a permitted person/entity can transport biomedical waste in specially designed vehicles to prevent scattering, escaping, flowing, spillage or leakage of the waste. It was of interest to this study to establish whether hazardous biomedical waste was segregated at the Hospital. In terms of awareness of staff on waste segregation, field findings indicate that 64.2 per cent of the respondents were aware of waste segregation at source, as a major biomedical waste management practice. It was also a requirement that all departments in the Hospital segregate their waste before transportation to final disposal, using color codes as shown in Table 3. It was observed that the colour coded bins were provided in all departments and the practice was being adhered to in most departments. However, there was evidence of some wastes being mixed. For instance, the laundry room received linen from different departments with mixed wastes. The study findings also indicate that some waste handlers mixed waste either due to neglect or lack of awareness by some staff members. The Hospital managed mixed wastes mainly through incineration. The practice of waste segregation in hospitals using colour coded bins is well documented. For instance, Sengodan 2014, in a study on segregation of biomedical waste in a South Indian tertiary care hospital, established that waste was segregated into three color coded bags, red bags for highly infectious waste while blue and yellow bags were used for non-infectious waste. In a study on self-reported healthcare waste segregation practices in five hospitals in Bale Zone, Ethiopia, Sahiledengle (2019) indicates that 53.8 percent of the healthcare workers who participated in the study practiced waste segregation. Gitonga (2017) established that although waste segregation was practiced in Chuka Level Four Hospital in Kenya using colour coded bins, mixing of hazardous and non-hazardous waste was common.

Table 3. Waste segregation colour code

Colour code	Type of waste
Red bins	All used swabs, catheters, gloves, IV sets, body tissues, contaminated paper, vacutainers and ampoules
Black bins	All paper waste, empty IV bottles, empty medicine bottles, paper hand towels
Yellow bins	All syringes, needles, surgical bottles, vials, cuvettes, ampoules, branulas
Green bins	All kitchen wastes

Source: Fieldwork 2013

It was established that all hazardous biomedical waste generated was treated before disposal. Table 4 shows the main treatment methods. Incineration, as a waste treatment method accounted for 66.7 per cent of the waste categories while steam sterilization accounted for 26.7 per cent of the categories. Decontamination using formaldehyde accounted for only 6.7 per cent of the waste categories. It was therefore evident that incineration was the most commonly used method of waste treatment followed by steam sterilization, using microwaving or autoclaving. The Hospital had two incinerators, an old smaller facility and a new one which was capable of handling larger volumes of waste. The new facility had the ability to incinerate at temperatures above 10000C and the Hospital carried out annual environmental audits on it. It therefore fully complied with the requirements of the Environmental Management and Co-ordination (Waste Management) Regulations. Plate 1 shows the new and old incinerators in the Level IV Hospital. The use of incineration to manage biomedical waste is widespread (Gautam et al. 2010, Velzy et al. 1990, Glasser et al. 1991, Klangsin and Harding 1998, Gitonga 2017).

Table 4: Treatment methods for biomedical waste in the Hospital

Waste category	Treatment method
Contaminated bodies	Incineration
Cultures and stock	Steam sterilization
Contaminated bedding/patient care waste	Steam sterilization
Contaminated small equipment	Steam sterilization
Contaminated large equipment	Formaldehyde decontamination
Waste biological	Steam sterilization
Surgery waste	Incineration
Human blood	Incineration
Autopsy	Incineration
Human blood products	Incineration
Contaminated laboratory waste	Incineration
Pathological waste	Incineration
Dialysis unit waste	Incineration
Contaminated and unused sharps	Incineration
Anti-neoplastic drug waste	Incineration

Source: Fieldwork data 2013

However, as already noted, the practice of incineration has negative environmental impacts. Biomedical waste incinerators have been associated with the emission of air pollutants and ash residues that are the major source of dioxins in the environment (Gautam et al. 2010). Furthermore, ash residues sent to landfills for disposal have the potential to leach into groundwater (WHO 2018).

Plate 1: New and old incinerators at the Hospital
Source: Fieldwork data 2013

As far as storage is concerned, it was established that each department had a sluice room where segregated wastes were stored before disposal. The wastes were collected by the housekeeping staff on duty from the point of waste production to the sluice room for further management. All wastes were collected daily by a contracted private waste company. Plate 2 shows a sluice room with waste bins and a used linen bag in the Hospital.

Plates 2: A sluice room with waste bins and a waste bag
Source: Fieldwork 2013

Onsite transport of waste was conducted using wheeled trolleys and carts that were easy to load and with no sharp edges that would damage waste bags and containers during load and unloading. They were also easy to clean. Plate 3 shows a wheeled trolley that was used in the hospital for onsite transportation of waste. However, Gitonga (2017) established that on-site waste transportation in Chuka Level Four Hospital was carried out using wheelbarrows and containers, increasing the risk for waste spillage, injury and infection.

Plate 3: Wheeled trolley used for onsite transportation
Source: Fieldwork 2013

3.2.2 Staff awareness of waste management policies

The study sought to establish the level of awareness among respondents, of the Hospital policies and the National Environment Management Authority's (NEMA) Waste Management Regulations 2006, related to hazardous biomedical waste management. It has been shown that awareness of waste management policies enhances the enforcement and implementation of such policies. The Hospital's segregation policy encouraged waste segregation at source while the Environment, Health and Safety (EHS) Policy focused on protection of the environment and human health while enhancing safety. The waste recycling and waste disposal policies made provisions for biomedical waste recycling and disposal. The Hospital's needle prick policy gave emphasis to the management of needle prick injuries through for example, post exposure treatment. The NEMA policy/Regulations makes provisions for biomedical waste handling including waste segregation, treatment, storage and transport. Figure 1 shows the research findings.

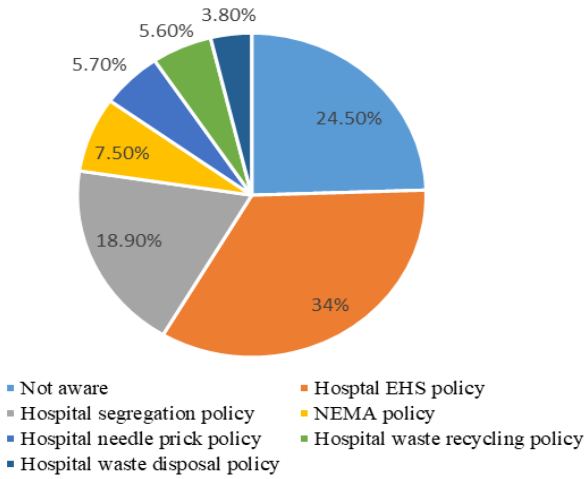

Figure 1: Staff awareness of policies governing biomedical waste management
EHS-environment, health and safety
Source: Fieldwork data 2013

Accordingly, 24.5 per cent of the respondents, mainly administrative and support staff, were not aware of any existing policies governing the management of biomedical wastes. However, a comparatively large proportion of staff (34 per cent) were aware of the hospital environment, health and safety (EHS) policy while 18.9 per cent were aware of the hospital waste segregation policy. The respondents were least aware of the hospital waste disposal policy. It is therefore evident that over 75 per cent of the study respondents were aware of the policies governing biomedical waste in the Hospital.

3.2.3 Staff awareness of hazardous biomedical waste handling and disposal practices

The study attempted to assess staff awareness of the Hospital waste handling and disposal practices. Figure 2 indicates the study results. Accordingly, 57 per cent of the respondents were aware of the Hospital biomedical waste handling and disposal practices. Incineration of waste was the most common waste handling practice. Waste recycling, involving waste water from the laundry machine and water used for rinsing utensils in the kitchen accounted for 4 per cent of the respondents while waste reduction involving reduction in paper production by use of an online platform for all stages of patient services accounted for 2 per cent of the staff. Only 2 per cent of the respondents were aware that the Hospital waste was disposed off through a private waste collection. The housekeeping staff were the main waste handlers after segregation from the departments and considering that the waste disposal site is quite a distance from most departments, the respondents were not aware that there was private waste collection. A significant percentage of the respondents were not aware of the Hospital waste handling and disposal practices. This is due to the sampling of respondents across all the departments including those that generated very little amounts of wastes or nonhazardous wastes and therefore didn't handle wastes beyond point of generation and disposal in the bin available for general wastes in their departments. There is also separation of roles and majority of the respondents not in the housekeeping department only segregated wastes at the source of generation and had nothing else to do with the handling and disposal.

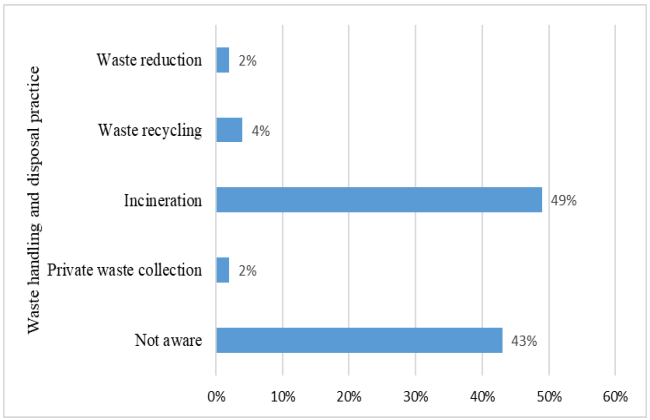

Figure 2: Staff awareness of Hospital waste handling and disposal
Source: Fieldwork data 2013

3.2.4 Waste management challenges and possible solutions

The study uncovered various challenges facing the management of biomedical waste in the study area, as shown in Figure 2. Mixing of wastes was cited by the largest proportion of the respondents (35.80 per cent) as the main challenge facing biomedical waste management. A relatively large proportion of the respondents (30.2 per cent) were not aware of any challenges related to waste management in their section/department while 15.1 per cent did not produce any biomedical waste in their section. The challenge of waste spillage was cited by 9.4 per cent of the respondents. This was mainly attributed to waste bins not being regularly emptied leading to overflow of waste. It was also evident that some waste handlers (7.5 per cent) ignored waste management procedures mainly due to negligence, lack of awareness/training. Lack of colour coded bins was cited the lowest proportion of respondents (1.90 per cent). The study findings concur with Tedesse and Kumie (2014) whose study on healthcare waste generation and management in health centres in Ethiopia established that the mixing of biomedical waste was a challenge to its management.

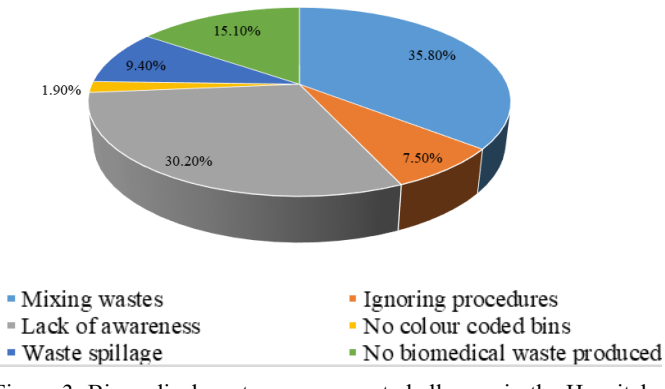

Figure 3: Biomedical waste management challenges in the Hospital:
Source: Fieldwork data 2013

Various solutions were suggested to address the waste management challenges. Table 5 shows the research results. A significant proportion of the respondents (41.9 per cent) were not aware of any solutions to the challenges of biomedical waste management mainly due to either lack of awareness of the challenges or non-production of biomedical waste. Further training in biomedical waste management was cited as the most significant solution to waste management challenges while 13.2 per cent of the staff indicated that there was need too to enhance staff awareness on waste management strategies and policies. The other suggested solutions were the need for close monitoring and adherence to set standards and procedures; reduction of colour codes for ease of identification; waste recycling, and the allocation of more resources for biomedical waste management.

Table 5: Suggested solutions to biomedical waste management in the Hospital

Suggested solution	Percentage
Awareness enhancement	13.2%
Biomedical waste management training	30.2%
Close monitoring	1.9%
Prompt waste collection	7.5%
Recycling of waste	1.9%
Reduction of colour codes	1.9%
Resource allocation	1.9%
Not aware of any solution	41.9%
Total	100%

Source: Fieldwork data 2013

The significance of training and awareness enhancement factors in biomedical waste management have been underscored by other studies. Basarkar (2014) in a study on whether effective and structured training is key to successful biomedical waste management in Seven Hills Hospitals in India, established that training increases knowledge and improves awareness leading to better waste management. Pandit et al. (2005) in a study of hospitals in Gujarat, India established that training of staff, both technical and non-technical, was critical for the proper and appropriate management of biomedical waste. Ozder et al. (2013) in a study on hospitals in Istanbul, demonstrated that hospital managers had insufficient knowledge on the most important problems of disposal of medical waste, prior to receiving training on waste management.

Conclusion

It is concluded that although the Hospital was safely and effectively managing hazardous biomedical waste through compliance with the provisions of the Environmental Management and Co-ordination (Waste Management) Regulations, 2006, it nonetheless needed to address the challenges associated with mixing of waste, either due to ignorance or lack of awareness of the procedures as well as waste spillage. The need for hazardous biomedical waste management training and awareness enhancement are recommended in addressing the waste management challenges, considering that separation of roles has majorly contributed to lack of awareness of waste management beyond the departments since the housekeeping department handled most of the wastes from source to final disposal. The departments that did not generate hazardous wastes did not have a reason to handle them while those that treated their wastes through autoclaving or microwaving did not have to involve the other departments in these processes. There is also need to interrogate the likely environmental implications of incineration as a biomedical waste management practice in Kenyan Hospitals.

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